Compressed Air Magazine

Vol. 42, No. 4 London - New York - Paris April, 1937

INAUGURATING CONSTRUCTION OF THE DELAWARE AQUEDUCT

ACKNOWLEDGMENT

AMONG the illustrations in the article on *The Diesel Engine—Past and Present*, which appeared in our March issue, there is a chart showing annual sales of diesel engines in the United States since 1915. That part of it covering the years 1915 to 1934, inclusive, is a reproduction of a chart compiled and copyrighted by the magazine *Diesel Power*. The figures for 1935 were obtained from Government documents, and the sales for 1936 were estimated. We hereby make due acknowledgment to *Diesel Power*, and express our regret that credit was not given at the time of publication.

•

IN THIS ISSUE

IN THE interest of accuracy, C. C. Hansen consulted the patent records when preparing his article on rock-drill history. Because of its brevity, some minor sins of omission may have been committed; but, on the whole, it is an authentic portrayal of the highlights of rock-drill development. It is significant to note that it was primarily Yankee ingenuity that solved the knotty problems of drill design.

•

BRUNORIZING, a new method of heat-treating steel rails, takes its name from that of John Brunner, formerly a consulting engineer of the Carnegie-Illinois Steel Corporation. Compressed Air is used for end quenching, and imparts to the rails, from the ends to the midsection, whatever gradation of hardness may be desired.

•

SELDOM do we find a municipality and a private company uniting to finance such an undertaking as the new Charleston, S. C., water-supply system. Just as infrequently do geological conditions permit a tunnel to be driven as fast as it was in this case. And even less often do we find a city providing for its water requirements for several centuries to come.

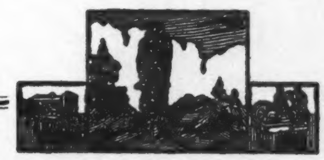
•

THE costliest piece of waterworks construction ever undertaken got underway on March 24 amid a flourish of oratory. Near Gardiner, N. Y., not far from Rip van Winkle's fabled domain, Mayor La Guardia of New York City touched off the inaugural blasts of the Delaware Aqueduct. "This", said the city's chief executive, "is a thrill that comes once in the lifetime of a mayor." The construction men were thrilled, too, but, withal, a little bored and impatient to get down to serious business. One high-booted worker summed up their sentiments when he shouted immediately after the ceremonies: "Now, bring on those rock drills!" The sharp reports of detonating dynamite will reverberate through the Catskills often during ensuing months. As the shafts grow deeper, and the blasts become muffled, one can fancy the shade of Old Rip cocking an ear toward the booming and imagining he hears again strange, bearded men playing at ninepins.

Compressed Air Magazine

Volume 42 **APRIL, 1937** Number 4

C. H. VIVIAN, *Editor* A. M. HOFFMANN, *Assistant Editor*
J. W. YOUNG, *Advertising Manager* J. F. KENNEY, *Business Manager*
D. Y. MARSHALL, *European Correspondent*, 243 Upper Thames St., London, E. C. 4
F. A. McLEAN, *Canadian Correspondent*, 620 Cathcart St., Montreal, Quebec.



EDITORIAL CONTENTS

ADVERTISING INDEX

A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

Published by Compressed Air Magazine Company. G. W. MORRISON, president; R. A. LUNDELL, vice-president; F. E. KUTZ, secretary-treasurer.

Business, editorial, and publication offices, Phillipsburg, N. J.

Advertising Office, 11 Broadway, New York, N. Y.

Annual subscription price: domestic, $3.00; foreign, $3.50. Single copies, 35 cents.

Compressed Air Magazine is on file in many libraries and is indexed in Industrial Arts Index.

Tunneling Eighteen Miles in Six Months

Contract for Sale of Water to Paper Company Enables Charleston, S. C., to Complete Project Started Nine Years Ago.

LOCAL COLOR

A view from The Battery, at the tip end of Charleston, toward the harbor that figured prominently in the Revolutionary and Civil wars. The tree is a palmetto. Charleston and its environs abound with historic structures, among which Fort Sumter is perhaps the most celebrated.

OCCASIONALLY, although not often, a municipality and a private industry jointly finance a project to provide a utility that both can use but that neither alone could afford to carry out. Such arrangements have usually worked out successfully in the past; and students of governmental and industrial trends predict that there will be more such dual undertakings in the future.

An outstanding example of this type of project is to be found at Charleston, S. C., where additional water-supply facilities are nearing completion. In this instance, the city is paying the direct cost of around $900,000 that is involved, but has been assured an increase in revenue of $30,000 a year for 50 years through the sale of water to the West Virginia Pulp & Paper Company. That income will more than meet the interest requirements of the bonds which were issued to finance the improvement. It is worthy of note that this pooling of public and private interests is enabling Charleston finally to secure water from a source that was first recommended in 1853, and to complete a supply system that was projected and partly built in 1928.

Just as interesting as its financial set-up are some of the physical features of the undertaking. The water will be delivered a distance of 23 miles through a continuous tunnel that penetrates at a relatively shallow depth a formation of such a character that no lining nor support is required. There are few places where Nature has endowed the subsurface so generously. The formation. which is classed as marl, contains

around 70 per cent of calcareous material, varying proportions of silicon and magnesium oxides, and approximately 17 per cent moisture. In addition, small amounts of aluminum and iron oxides, and traces of phosphorus and sulphur are usually present.

It is harder than average earth, but not so hard that it can be classified as rock. As a consequence of this stability combined with softness, it is possible to drive an opening through it both rapidly and economically. These favorable circumstances, together with the construction procedure that was employed, resulted in the completion of 18 miles of tunnel in a little more than six months of elapsed time.

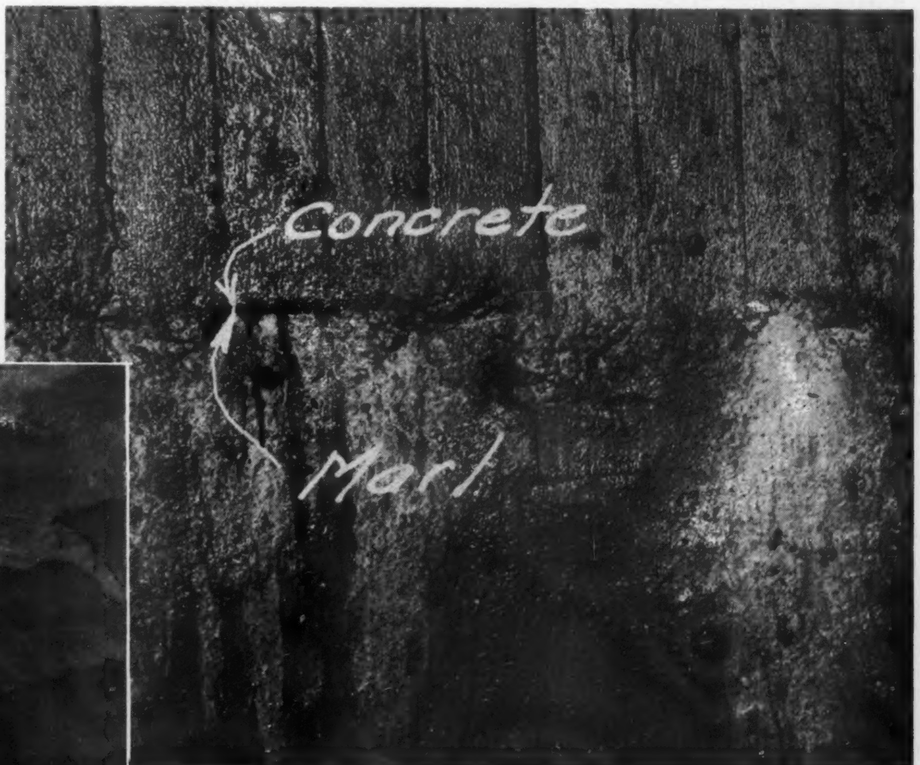
The project is officially designated as the Edisto River-Goose Creek Tunnel, and is being executed by the Commissioners of Public Works of the City of Charleston. It will divert water from the Edisto River to Goose Creek, the present source of supply, thereby permitting the use of the existing storage reservoir and of the distribution lines leading from it to the city, approximately 12 miles distant. The water that will thus be added to the supply will be sufficient to meet the normal expected requirements of the city probably for several centuries to come.

A brief review of the history of Charleston's water-supply system will disclose the conditions that led to the current development, and will also promote a clearer understanding of the important bearing it will have upon its future industrial growth. Charleston, which is known as one of the most picturesque and historic cities in the United States, was settled in 1670. It is located on a peninsula between the Cooper and Ashley rivers, about 7 miles from the open ocean. It has a fine harbor that accommodates vessels up to 30-foot draft and that has about 9 miles of waterfront. These facilities, together with its strategic location with reference to farm and forest lands, have made the city the leading port of South Carolina and one of the important commercial and industrial centers along the South Atlantic Coast. It is served by two major railroad systems and by several steamship lines.

Charleston is situated on ground that is nowhere more than 8 or 10 feet higher than the mean high-water level of the tidal rivers on either side of it. Prior to the construction of the works now in use, the city obtained its water from four artesian wells that had a combined daily output averaging 1,800,000 gallons and that were operated by a private company. That water issued from the ground at a temperature of 98°F. and, accordingly, had to be allowed to cool before it could be distributed. Also, it contained alkaline mineral salts which, while not harmful in themselves, had a peculiar effect upon certain foods. Rice, hominy "grits", and similar staple cereals of the southern dietary, when cooked in the water, became green because of the action of the mineral matter.

Housewives of that generation soon learned that the addition of a little vinegar to the cooking foodstuffs would counteract the alkalinity and restore to them their traditional appetizing whiteness. In after years, when other water was normally distributed, it occasionally became necessary during periods of shortage to draw upon the artesian wells. Unfortunately, many of the younger women were not familiar with this simple corrective formula, with the result that the water department would be besieged with protests that the family "grits" had been ruined and no one would eat them.

As previously mentioned, the Edisto River was first considered as a source of supply in 1853. At that time a firm of

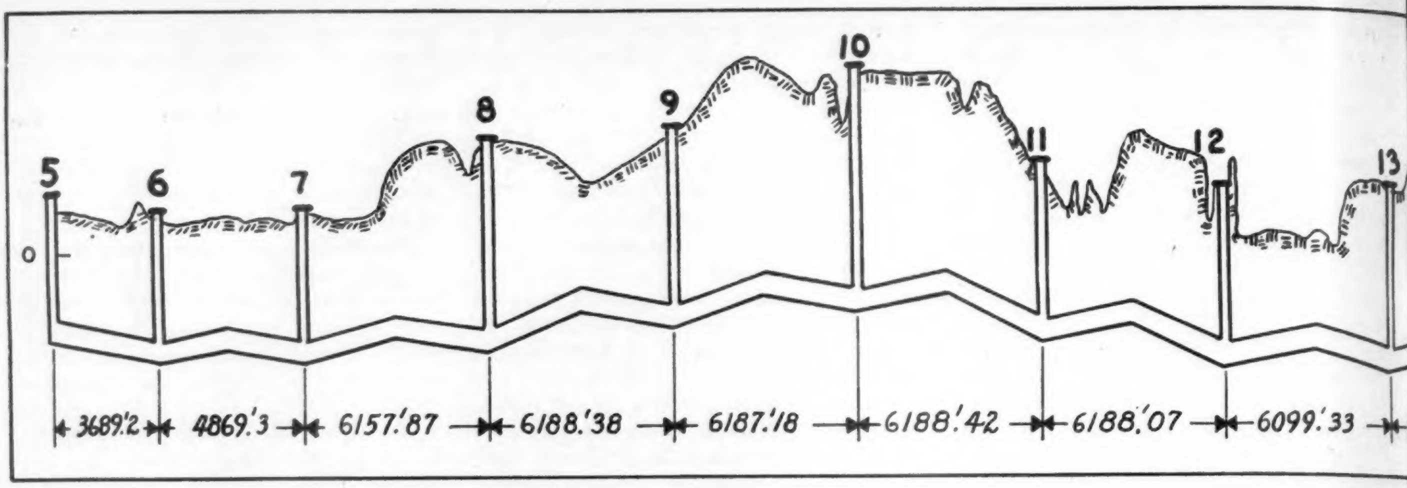


CONCRETE-MARL CONTACT

All shafts were lined with concrete from the surface down to the marl prior to the excavating of the tunnel, and will be completely lined before the aqueduct goes into service. This picture of the junction between the concrete and marl was taken six months after the lining had been placed, and shows that practically no displacement nor spalling of the marl had occurred during that period of exposure.

EXCAVATING WITH A CLAY SPADE

At one of the tunnel headings, showing the appearance of the walls and roof prior to trimming. Ordinary procedure was to drill five holes in the breast, shoot them with light charges of explosives, break up oversize pieces with clay spades, and load the muck by hand. Walls and roof were trimmed to finished lines as excavating proceeded. After a section had been holed through, the floor was taken up to final grade and all tracks and other construction facilities removed.



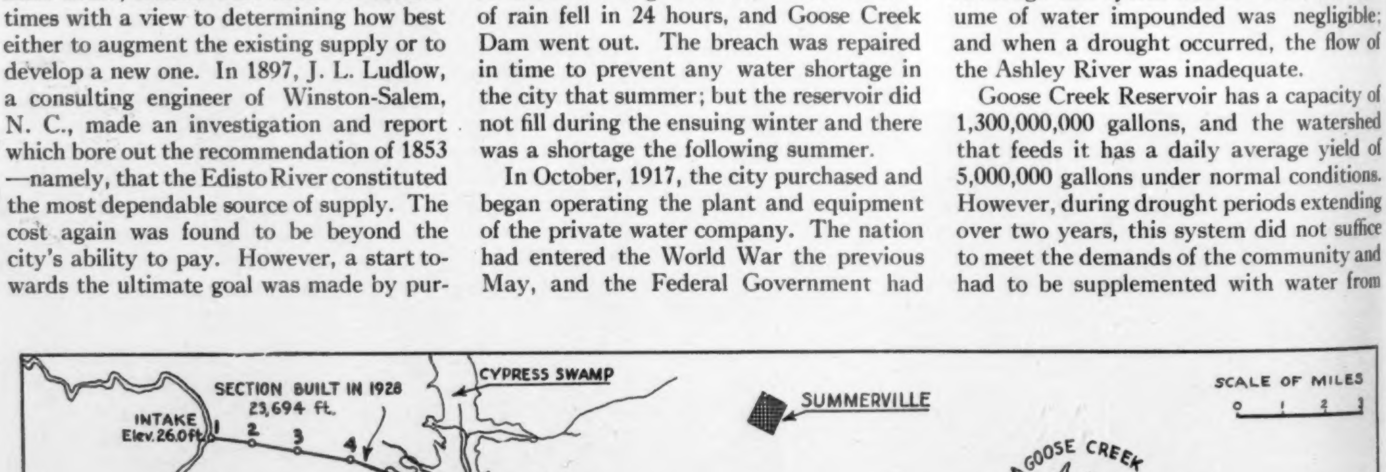
engineers, commissioned by the city to make a survey, reported that that stream was the only one of the sources available on which dependence could be placed. It was then estimated that it would cost approximately $1,900,000 to construct the facilities that would be required for the delivery of 4,000,000 gallons a day. As the annual revenue—based on a population of about 50,000—was but $67,700, only 3.6 per cent of the outlay, the scheme was held to be economically impractical and was therefore dropped.

Towards the end of the last century, when the artesian wells became inadequate and the shortage of water grew more and more acute, studies were made at various times with a view to determining how best either to augment the existing supply or to develop a new one. In 1897, J. L. Ludlow, a consulting engineer of Winston-Salem, N. C., made an investigation and report which bore out the recommendation of 1853—namely, that the Edisto River constituted the most dependable source of supply. The cost again was found to be beyond the city's ability to pay. However, a start towards the ultimate goal was made by purchasing 1,500 acres of land along the banks of the Edisto River at the point which had been selected as the one most suitable for the diversion works.

In the meantime the output of the four artesian wells had been increased from 1,800,000 gallons per day to 2,500,000 gallons by the installation in 1893 of air-lift pumps. Even then there was a shortage that was growing more serious year by year; and when the city failed to provide additional facilities, private interests in 1902 constructed a dam on Goose Creek, some 12 miles north of it. This source assured a supply of around 5,000,000 gallons a day in normal years and proved adequate for the time being. In 1916, nineteen inches of rain fell in 24 hours, and Goose Creek Dam went out. The breach was repaired in time to prevent any water shortage in the city that summer; but the reservoir did not fill during the ensuing winter and there was a shortage the following summer.

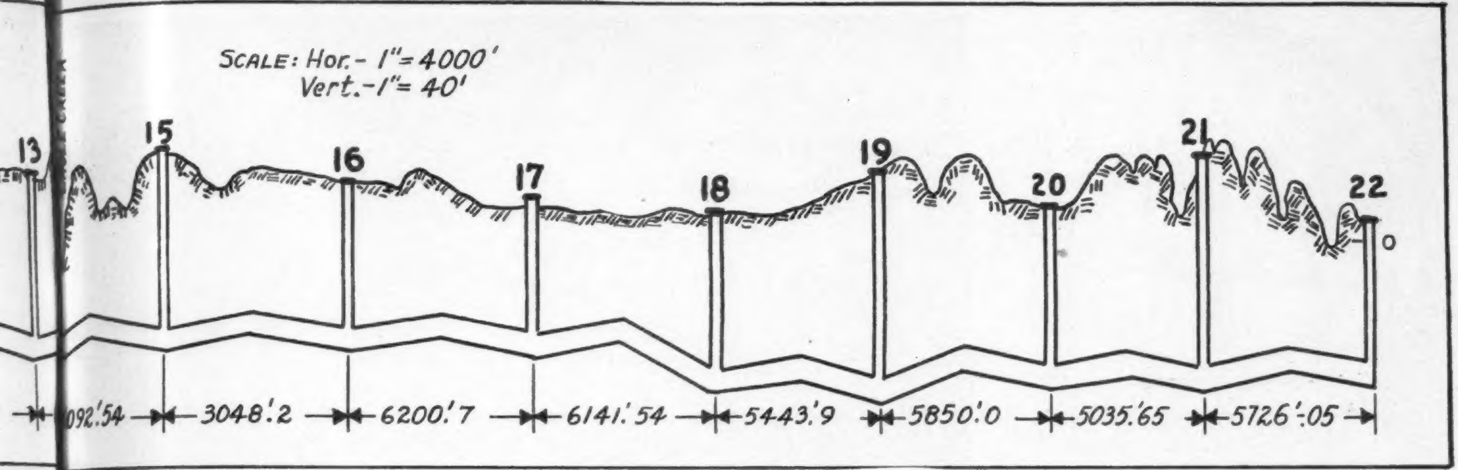
In October, 1917, the city purchased and began operating the plant and equipment of the private water company. The nation had entered the World War the previous May, and the Federal Government had made demands on the municipal water department for additional supplies for the navy yard and the port of embarkation which were under construction at North Charleston on the Cooper River. After a hurried study of the situation, U. S. Army and city engineers jointly proceeded to increase the supply by developing the Ashley River. A timber-crib dam was built at Bacon's Bridge to prevent tidal salt-water intrusion, and an oil-engine pumping station was established nearby to pump the Ashley River water that was impounded there through 4 miles of 24-inch wood-stave pipe into an open canal, 5 miles long, for delivery to the Goose Creek storage basin. Although this sytem was of value, the volume of water impounded was negligible; and when a drought occurred, the flow of the Ashley River was inadequate.

Goose Creek Reservoir has a capacity of 1,300,000,000 gallons, and the watershed that feeds it has a daily average yield of 5,000,000 gallons under normal conditions. However, during drought periods extending over two years, this system did not suffice to meet the demands of the community and had to be supplemented with water from



ROUTE OF TUNNEL

The section just excavated is indicated by the heavy line, with the shafts designated by circles. As shown, it connects at the upper end with a 4.48-mile section that was driven in 1928. The latter made it possible to deliver Edisto River water to Goose Creek Reservoir by the following means: From Shaft No. 5 it flowed in a canal to the Ashley River, down that stream for a distance of 9.8 miles to Bacon's Bridge, whence it was pumped through nearly 4 miles of pipe line to another canal that carried it to Goose Creek. Should the new section of the tunnel go out of commission for any reason, it would be possible similarly to supply water and to continue service while repairs were being made. Charleston is situated approximately 12 miles south of the Hanahan pumping station, and water for city consumption is pumped through two pipe lines to a tower situated there. The new paper mill that will use much of the water is at the right of the area mapped.



LONGITUDINAL SECTION

The tunnel was advanced from seventeen vertical shafts having depths of from 40 to 72 feet. It penetrates a marl formation throughout its length, and has a minimum cover of 20 feet. The ground surface irregularities and the rise in tunnel grade between each adjacent pair of shafts are exaggerated because of the difference in the horizontal and vertical scales of the sketch. The tunnel was driven a distance of 18.6 miles, and required the excavation of 150,000 cubic yards of material.

the old artesian wells. This was the case in 1918 and again in 1927. These droughts, together with the growing consumption of water, made it increasingly necessary to develop further sources of supply, and in 1926 the engineers of the water department were authorized to make a study of available resources. Following an extensive investigation of all the streams in the area, the Edisto River was recommended, and it was specified that the water should be taken from it at the point that had been selected in 1853 and again in 1897.

The cost of this development was a stumbling block until investigations of the subsurface revealed that a tunnel driven through the marl would not have to be lined. It was further discovered that the project could be carried out in stages, and that the completion of the first stage would make it possible to deliver Edisto River water to the Goose Creek Reservoir with the aid of existing facilities. The 1927 drought made action imperative, and construction of the first stage was authorized in 1928. Inspection of the accompanying map will help the reader better to understand the description that follows.

It will be noted that the Edisto River flows generally southward and about 23 miles west of Goose Creek Dam, which is, in turn, almost due north of Charleston. The ultimate plan contemplated the boring of a tunnel through this intervening territory. It will also be observed that the upper reaches of the Ashley River extend to within a short distance of the point at which water was to be diverted from the Edisto River, and that it flows in a generally eastward direction for several miles. Advantage was taken of these physical features in developing the first stage of the system.

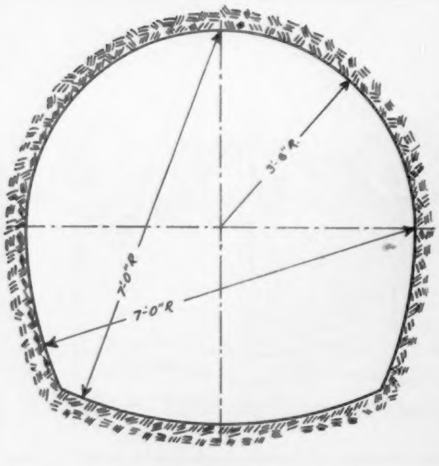
A tunnel was driven eastward from the Edisto River for a distance of 4.48 miles, the work being done by the MacDougald Construction Company of Atlanta, Ga. It was finished in January, 1929, and is known as the Jahnz section. From the outlet shaft of this tunnel an open canal was excavated for about 2 miles to the Ashley River. Water thus delivered from the Edisto to the Ashley could be taken out 10 miles downstream at Bacon's Bridge and diverted to the Goose Creek Reservoir through the pipe line and canal that had been built in 1917-18. In 1931, it became necessary to call upon these facilities to supplement the Goose Creek supply for a period of five months.

As previously stated, this was regarded as a temporary solution of the problem. It was the intention to carry the tunnel through to Goose Creek Dam as soon as the city's financial position was such as to permit it. The objection to the system as it then existed was the great loss of water resulting from evaporation, from seepage, and from the nourishing of vegetation in the swamp areas traversed by both the Ashley River and Goose Creek. Furthermore, with the completion of the tunnel, there would also be obviated the need of a pumping station at Bacon's Bridge. The foregoing account covers the developments up to the time that the current program was undertaken.

In 1935 the West Virginia Pulp & Paper Company began an investigation of the Charleston area with a view to locating a mill there for the manufacture of kraft paper and related products. Satisfactory transportation facilities existed; but another essential was a sizable and dependable supply of water. Having knowledge of the fact that the city had already projected a plan for the extension of the tunnel, the company entered into negotiations with the municipal authorities with the result that a mutual agreement was reached whereby

INTERIOR OF TUNNEL

While tunneling was in progress the floor was carried about 5 inches above grade, except for ditches cut at either side to carry water to each shaft bottom, whence it was pumped to the surface. During the final trimming operations the tracks were removed and the excavating of the bottom completed.



CROSS SECTION

The tunnel has a cross section of 40.65 square feet, and its daily carrying capacity will be 50,000,000 gallons under gravity flow and as much as 80,000,000 gallons under pumping.

AT A SHAFT BOTTOM

A cage and loaded muck car at the foot of Shaft No. 21. The picture was taken on January 29, 1937, at which time hoisting had been carried on for six months. It will be noticed, however, that there had been no sloughing of the marl and that the intersection of the shaft and tunnel was still sharply defined.

the system which had been started in 1928 was to be completed. This involved the building of 18.6 miles of tunnel which, it was estimated, would cost approximately $1,000,000. To finance the construction, the city issued $1,000,000 in 3 per cent bonds to mature serially, beginning with 1940. When sold, these bonds brought $980,000. Present indications are that the cost of the work will not amount to more than around $900,000, or 10 per cent less than it was expected to be.

The tunnel is of modified horseshoe shape and 7x7 feet in maximum dimensions, or the same size as the 4.48-mile section at its head end connecting it with the Edisto River. The combined length of both sections is 23.08 miles. The intake is at elevation 26, and the full-water pool level of Goose Creek Reservoir, into which the tunnel will discharge, is at elevation 7. This drop of 19 feet will provide a gravity-flow capacity of 50,000,000 gallons daily. By installing pumps with a suction lift to permit the raising of water from elevation −13, it will be possible to increase the capacity to 80,000,000 gallons.

The contract with the paper company calls for the delivery of a minimum of 25,000,000 gallons a day and provides for an increase in quantity in the future should the demands of the mill rise. Charleston's present consumption averages around 5,000,000 gallons daily, which, it is of interest to note, is only one-fifth of the volume that will be used by the paper mill. The population within the city totals approximately 62,000, and water is supplied to some 6,000 or 7,000 persons outside the city limits. The per capita consumption is about 73 gallons daily. The minimum flow of the Edisto River is approximately 150,000,000 gallons per day, or almost double the maximum amount of water which the tunnel will divert when operated at full pumping capacity.

As soon as its contract with the city had been drawn up in 1935, the West Virginia Pulp & Paper Company began the preparation of plans for its new mill with the expectation of having it ready for service by July 1, 1937. It was therefore necessary that the tunnel should be built without delay; and steps were taken to start construction as soon as practicable, to outline the procedure, and to organize the operations to the end that water would be available by the time the mill was ready for the manufacture of paper.

The Commissioners of Public Works decided to carry out the construction program rather than to let contracts. The plans and all other engineering phases of the project have been handled by the Water Department under the direction of J. E. Gibson, manager and engineer, and his assistant, F. B. McDowell, Jr. Because of its interest in the tunnel, the West Virginia Pulp & Paper Company has lent assistance through its consulting engineers. Robert E. Parker, of New York City, was retained as superintendent of construction. Mr. Parker has had wide experience in that capacity, having been in charge, among other undertakings, of the driving of the tunnels on the Pigeon River project, in North Carolina, of the Carolina Power & Light Company, and of the building of the Wanaque Dam of the Newark, N. J., and environs water-supply system.

While Mr. Parker was engaged in the first-mentioned work, in 1928, he was called to Charleston to render an opinion as to whether the explosives used in excavating the section of the Edisto Tunnel then under way would shatter and weaken the marl formation to the point where the bore would have to be lined in order to give satisfactory service. At that time a consulting engineer, retained by the city, had expressed the belief that the use of explosives should be prohibited; and, as a consequence, the contractor was ordered to stop blasting. The contractor protested, and requested that an experienced construction man be called in to make an investigation and report. Mr. Parker was selected for this service; and he upheld the contention of the contractor that blasting was not endangering the stability of the marl. As a result of that opinion the use of explosives was continued throughout the driving of the 4.48-mile section.

Before work on the current program was started, the original tunnel section was unwatered and carefully inspected for the purpose of determining whether the construction procedure previously followed should be modified. Although it had not been carrying water steadily during the intervening years, it had been standing full of water all the while. Observations revealed that no sloughing of wall or roof material to speak of had taken place, and that the tunnel, after seven years, was in good condition. As a consequence, it was decided to build the remaining section without a lining. Naturally, because of Mr. Parker's connection with the driving of the first link, he was thoroughly acquainted with the ground conditions, and this was of aid to him in formulating suitable construction methods for the work he was to direct.

The surface material in the area traversed by the tunnel consists of sand, sandy clay, and alluvial matter varying in thickness from 3 to 40 feet. The surface elevation

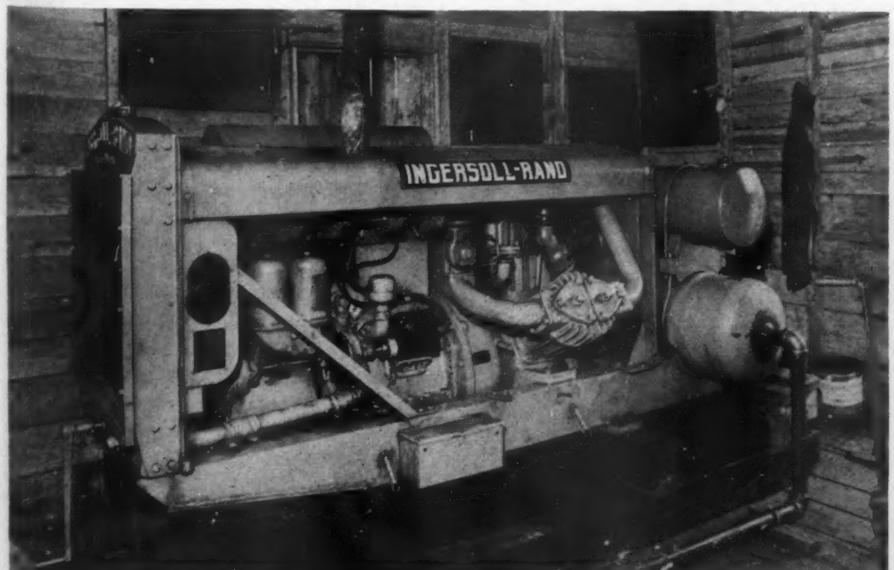
ranges from about 10 feet to 70 feet above mean sea level. Immediately below the overburden is a sandy marl that measures all the way from a thin edge to as much as 9 feet, with an average thickness of around 2 feet. Geological study indicated that this formation was originally thicker and that it was washed away to some extent at the time the sea which had deposited it receded. Sea shells and fossils in abundance are found in it.

Just beneath the sandy marl is the so-called hard marl in which the tunnel was driven. This material displays remarkable continuity and freedom from faults, fractures, or breaks of any sort. In addition to these favorable characteristics, it is homogeneous and, as mentioned at the outset, hard enough to stand up well without support and soft enough to permit fast and inexpensive penetration. The entire tunnel extends through this marl and has a minimum cover of 20 feet and a maximum of around 72 feet. As the top of the marl is generally at elevation around 0, the tunnel is below sea level throughout its course.

HEADHOUSE AND TOWER

Each of the seventeen shaft sites became a temporary mining location and was provided with the machinery and facilities required for hoisting excavated material. All these surface plants were alike. In the headhouse at the left were a portable air compressor and a gasoline-engine-driven hoist. The headframe was of 12x12-inch timbers. Loaded cars of muck were hoisted to the trestle level and run off to a dump.

Access to the tunnel grade was obtained by sinking seventeen shafts along the 18.6 mile line. These are spaced from 3,686 to 6,204 feet apart; are circular in section and 9 feet in diameter; and are concreted as far down as the top of the marl. This lining will be extended to the bottom before the tunnel is placed in service. A 12x12-inch timber headframe, about 35 feet high, was erected over each shaft. Cages designed and made on the job were installed in fifteen of them while the two others were equipped with buckets. A United Hoist, driven by a Ford V-8 industrial-type gasoline engine and having a single drum wound with ⅞-inch wire rope, served each shaft. Housed with it in a temporary building in each case was a 160-cfm. portable air compressor and a Marble-Card 5-kw., 115-volt generator powered by a LeRoi gasoline engine. Air was piped down each shaft through a 2-inch line for the operation of excavating tools and drainage pumps. The generator supplied current for electric lights underground at all times and for surface lights at night. Ground was cleared for the first shaft site on July 1, 1936, and tunnel driving started on August 21.



SOURCE OF COMPRESSED AIR

In the headhouse at each shaft was a 160-cfm. portable air compressor that supplied power for the operation of rock drills, clay spades, and drainage pumps in the tunnel. Ten of these machines were of the type shown, six of them being driven by oil engines and four by gasoline engines. An index to the reliability of modern units of this sort is found in the fact that the time lost through mechanical troubles was less than one-half of one per cent of the operating period. All the difficulties were of a minor nature, and the greater part of the time lost could have been avoided if it had been possible to keep a larger stock of spare parts at each of the shaft sites.

From the bottom of each shaft, headings were advanced in two directions. Work was accordingly carried on at 34 faces. The first section was holed through on January 7, 1937, and the final one on February 24. The average excavating time for each section was approximately five months. Operations at the headings were standardized. Drilling was done with 45-pound hand-held drills, there being one driller at each face. A round normally consisted of five holes of which four were disposed around the outside line of the tunnel section and one in the center. Auger steel of ⅞-inch section was used. The holes were loaded lightly with No. 1 Gelex and shot electrically. The material thus dislodged was thrown back only a few feet. Large pieces brought down were broken up with air-operated clay spades before the spoil was shoveled into cars by two muckers. From six to ten rounds were drilled, blasted, and loaded every 24 hours.

Muck cars of 18- and 21-cubic-foot capacity were employed. These ran on narrow-gauge tracks made of 20-pound rails. Approximately 100,000 feet of these rails, with patented metal ties, were furnished by the West Virginia Rail Company. Tramming was done by hand, with pushers stationed every 800 feet. Each man shoved a loaded car to the end of his section, where a switch was installed. There he turned the car over to his relay and received an empty, which he proceeded to push back.

The work of tramming was facilitated by the tunnel grade. From each shaft the bore slopes upward slightly to a point midway to the next shaft, the maximum gradient

being two-tenths of one per cent. The primary reason for this alternating series of rises and depressions is to provide natural drainage to the shafts in case it should ever become necessary or desirable to pump out individual sections for inspection or repairs.

It is the nature of marl to "sweat," and considerable quantities of water collected in the tunnel each day. To remove it, an air-operated pump was installed at the foot of each shaft. With the exception of one Ingersoll-Rand No. 25 Sumpump, they were all of the reciprocating-piston type. The pumps were operated intermittently, being in service from two to three hours daily.

At the shafts where cages were employed, the loaded cars were hoisted to the surface. In the case of the two shafts equipped with buckets, the muck was dumped from the cars into the buckets and, after being hoisted, was again dumped into other cars. In either case, the cars were pushed from the shaft head to the dump by hand. Before construction began, the surface area beneath which the tunnel runs was purchased outright, and sufficient land was included to provide sites for these dumps.

The methods just described were productive of unusually fast progress. The best record for one week was 6,600 feet, or an average of 194 feet per heading. Work was carried on in two 10-hour shifts, six days a week; but as each shift ordinarily worked from an hour to an hour and a half overtime, the operations were practically continuous. During the weekly one-day shutdown on Sunday, machinery and tools were inspected, oiled, and repaired. A bonus system had the effect of keeping activity at top speed. Under this plan, foremen, drillers, and muckers were paid 50 cents and car pushers 25 cents for every foot of advance over 8½ feet made each day at each heading, the progress being figured on a weekly basis. In addition to the underground workers, there were three top men and a cage man on the surface at each shaft. At the height of operations, approximately 1,100 men were employed.

It is readily apparent that for an undertaking of this nature, where speed is one of the principal considerations, dependable equipment is indispensable. At the same time, economy loses none of its importance. It is therefore of interest and value to note the record of some of the portable air compressors that served on this project. Of the seventeen machines used, ten were manufactured by Ingersoll-Rand Company, and all ten were of the new type having 2-stage, air-cooled compressor ends. Four of them were powered by gasoline engines, and the remaining six by the company's Type H, spark-ignited oil engines. Throughout the tunneling period, according to those in charge, the total time lost because of failure of these ten compressors aggregated not more than two and one-half shifts for one heading. It is further stated that most of the enforced shutdowns could have been avoided had the stock of spare parts been adequate, as the trouble in no case was of more than a minor nature.

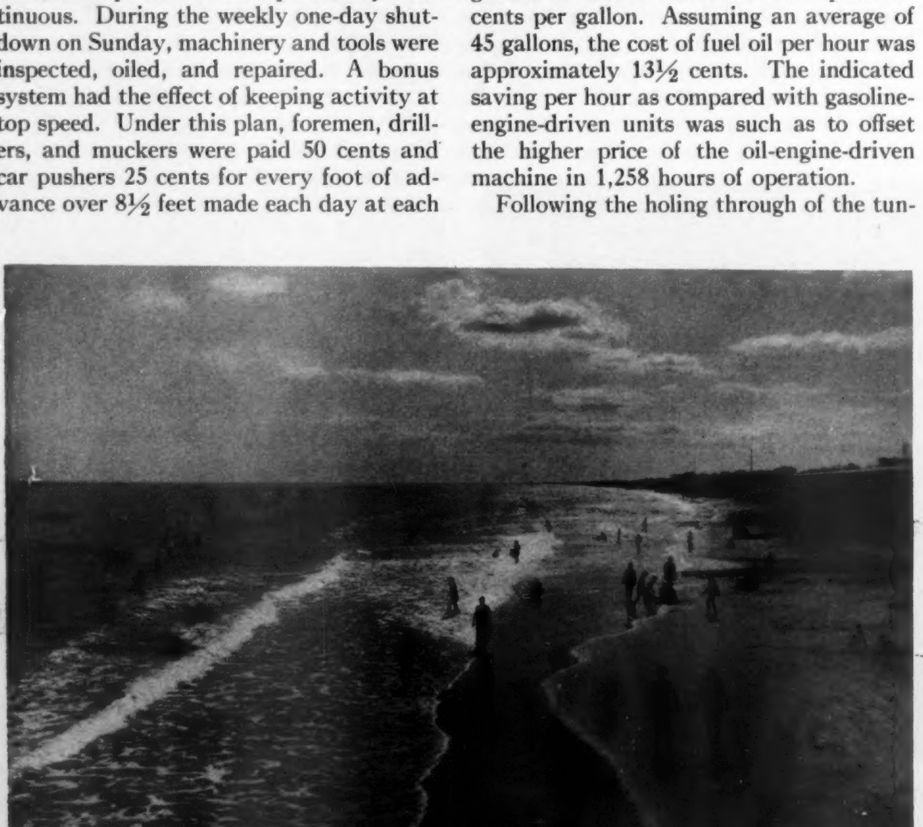
The project also served to demonstrate the low cost of operating the oil-engine-driven compressors. The records indicate that they consumed daily from 40 to 50 gallons of fuel oil for which was paid 7.2 cents per gallon. Assuming an average of 45 gallons, the cost of fuel oil per hour was approximately 13½ cents. The indicated saving per hour as compared with gasoline-engine-driven units was such as to offset the higher price of the oil-engine-driven machine in 1,258 hours of operation.

Following the holing through of the tunnels, they were trimmed to line. The sides and roof were originally excavated to full size and with smooth surfaces, so the latter work consisted principally of taking up approximately 5 inches of surplus material that had been left in the bottom and of removing the tracks, air lines, power cables, etc. For the trimming operations, it was the practice of the crew in each section between two adjacent shaft bottoms to start at the apex of the grade in the center and to work back toward the shafts. Such a crew normally consisted of four men with adzes, two with air-operated spades, four muckers, and four car pushers.

From Shaft No. 22, at the lower end of the Edisto River-Goose Creek Tunnel, an additional section 653 feet in length was driven by the same forces for the West Virginia Pulp & Paper Company. At the end of that section is another shaft, through which the water for plant use will rise. At that point there will be installed four pumps with respective capacities of 10,000,000, 15,000,000, 25,000,000, and 25,000,000 gallons per day. They will provide a flexible plant by means of which the quantity of water pumped can be widely varied. Provision has also been made for pumping from Goose Creek Reservoir, if that is desired. In either case, the water will be delivered through approximately 18,000 feet of lock-joint concrete pipe to a reservoir at a sufficient elevation to assure a head of 40 feet at the paper mill.

As surface soil in the Edisto River drainage basin is sandy, the water is free from turbidity and is very soft, its hardness being only 10 to 12 parts per million. In common with most water in the region, it is of a pronounced brownish color, which is imparted to it by the vegetation in the swamps which the stream drains. The coloration is not harmful, but it will be removed from the water for Charleston consumption in the present filter plant located at the Goose Creek Reservoir. The full course of treatment provides for coagulation with alum and sodium aluminate, aeration, filtration, and the addition of enough caustic soda to overcome the slight acidity of the water in its raw state. From the treatment works the water is pumped through one 20-inch and one 24-inch pipe line to an elevated tank in Charleston which provides for gravity distribution to the consumers.

Although the underground work connected with the tunnel has occasioned little difficulty, numerous surface obstacles have had to be overcome. Much of the route traversed, particularly at the upper end, is in areas of heavy vegetation and swamps. As a result, some of the shaft sites became difficult of access after the rains started in the autumn. The worst conditions prevailed at Shafts Nos. 6 and 7, to which all materials and supplies have had to be transported on muleback since last November. Although these shafts are less than a mile apart, it is necessary to make a journey of 26 miles to go from one to the other by automobile.

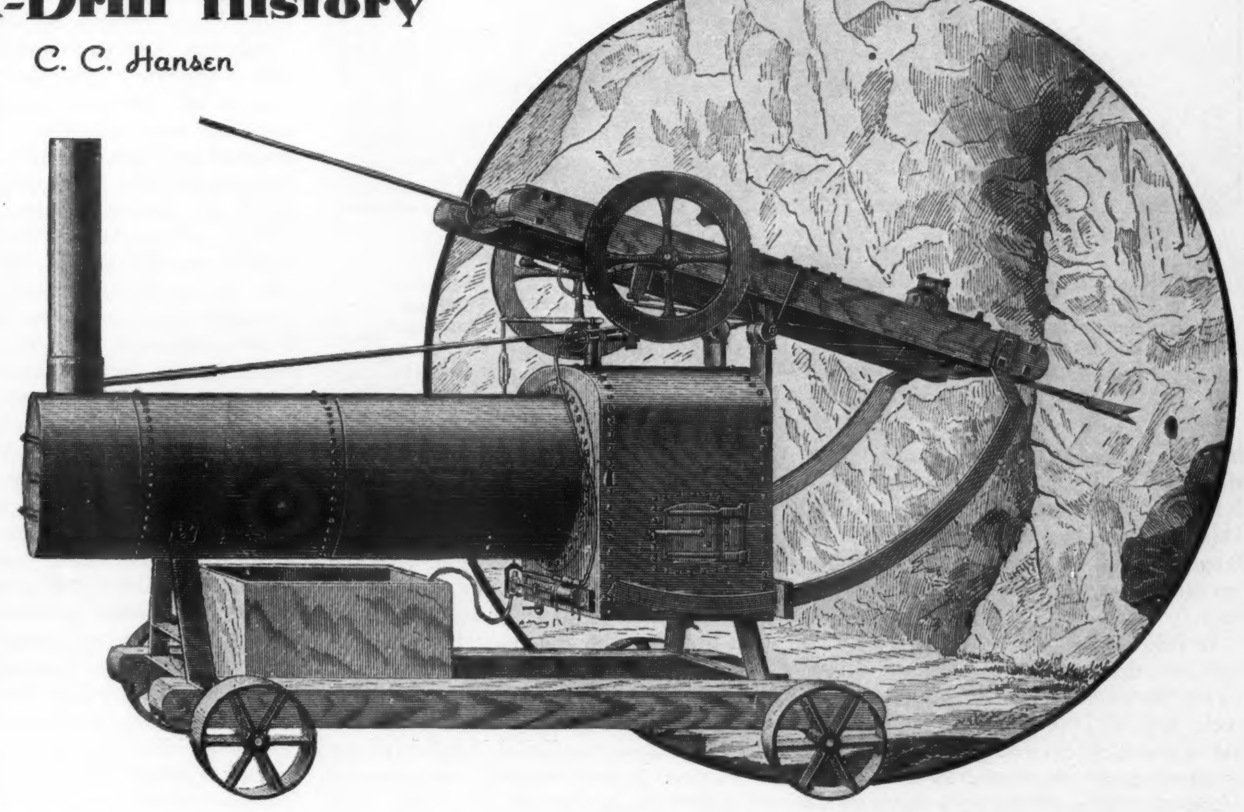


FOLLY BEACH

Charleston is favored with a semi-tropical climate that attracts many tourists and vacationists. Three beaches near the city offer excellent facilities for surf bathing. This one is located south of Charleston.

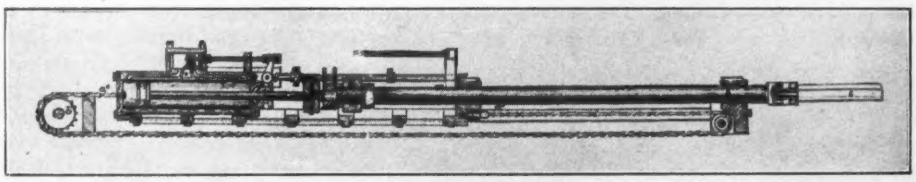
Rock-Drill History

C. C. Hansen



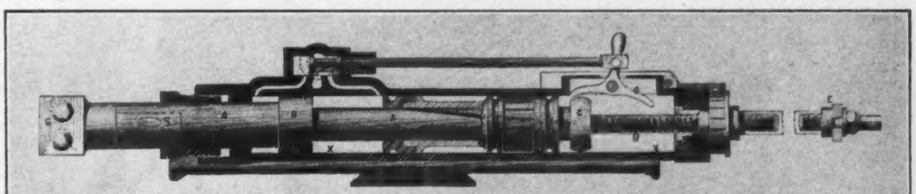
FIRST MECHANICAL ROCK DRILL

This ponderous machine, mounted on top of the boiler that supplied the steam for driving it, was patented by J. J. Couch on March 27, 1849. It bore little resemblance to later drills, but it probably did serve to start men with inventive minds to pondering the problem of drilling rock mechanically. Couch's drill was provided with means for catapulting the steel against the rock face and then retracting it. That, in effect, was the principle upon which was based the piston drill that came later and that persisted until Leyner devised an effective hammer drill. The Couch drill was used experimentally, but there is no record that it was ever applied commercially.



THE FIRST FOWLE DRILL

J. W. Fowle got his idea for this original piston drill while working with Couch. He filed his caveat in 1849, and in 1851 received a patent that covered certain improvements. This drill was designed automatically to rotate the drill steel, which was clamped to the piston, and had a mechanically operated valve motion. It was the first machine that possessed all the essential features of a practical rock-drilling machine.



THE BURLEIGH DRILL

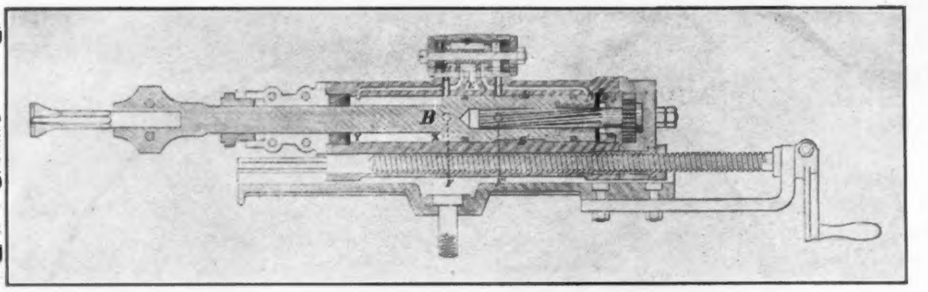
The drilling of the Hoosac Tunnel, the first railroad bore driven in the United States, prompted Charles Burleigh to invent the drill shown, which was a modification of the Couch and Fowle patents. About 40 of them were used in the Hoosac Tunnel; but it is recorded that the expense for repairs was enormous. In 1868, two years after it was introduced, Burleigh redesigned it, and the tunnel was finished in 1873 with the improved machines. Burleigh drills later became very popular and were employed extensively.

NO CONSECUTIVE history of the rock drill is to be found, only fragmentary sketches that advertised one or another of the different styles of construction. For that reason it is difficult to obtain a complete and unbiased review of the subject.

The rock drill, like all other important machines, was gradually developed from hand tools and met the usual obstacles and prejudices. Opposition to changing from hand to mechanical drilling could be overcome only by showing a tremendous advantage in cost and speed in favor of the new method. This transition naturally extended over a long period of time. The early drills were not always accepted, nor did they meet the requirements of all drilling conditions. Improvement came by degrees, and a great many minds worked on the development of a satisfactory machine.

An accurate index to this development exists in the form of the United States patents that were issued to the different inventors. This record discloses the date on which each application was entered and on which each patent was granted, and, when combined with the established history of the successful concerns that have long been making drills, apparently constitutes the most authentic account of rock-drill progress obtainable today. The following data are based on these records.

While digging the Illinois and Michigan Canal in 1838, two brothers, Isaac M. and John A. Singer, built a number of drop drills for the rock work. The drill steel was lifted with a steam piston; but the drop or



SECTION OF "ECLIPSE" DRILL

This drill took its name from the valve which was invented by Henry C. Sergeant and which was an improvement on the cam or tappet-valve motion of the Fowle and Burleigh drills. The "Eclipse" valve was the first to be operated by steam or air pressure and without a metallic connection with the piston. This type of drill was manufactured for many years by the Ingersoll Rock Drill Company and its successor, the Ingersoll-Sergeant Drill Company.

blow was by gravity, and the drills could therefore produce only vertical holes. It is interesting to note that one of those men, Isaac M. Singer, was the inventor of the Singer sewing machine; but the name Singer does not again appear in rock-drill patents.

In 1849, J. J. Couch applied for a patent on a rock drill. The steel was not attached to the piston, but was thrown against the rock, and no provision was made for rotating the steel between blows. This machine was purely experimental and was not employed on any actual work so far as the available records show.

J. W. Fowle, in 1851, secured U. S. Patent No. 7972 on a percussion rock drill (piston rock drill) with the steel clamped to the piston rod, with mechanical valve motion, and with automatic rotation of the steel. This seems to have been the first drill to embody all the features necessary to the successful operation of a machine intended for rock drilling. Fowle had been with Couch while the latter was experimenting prior to 1849; and as he took out a caveat in 1849 on his idea, with claims broad enough to cover the principle of the percussion rock drill as later built and actually used in rock drilling, his was no doubt the most important attempt up to that time to cover the field. Fowle's drills were employed on the Mont Cenis Tunnel in the Alps; but no extensive use of them in general work is traceable.

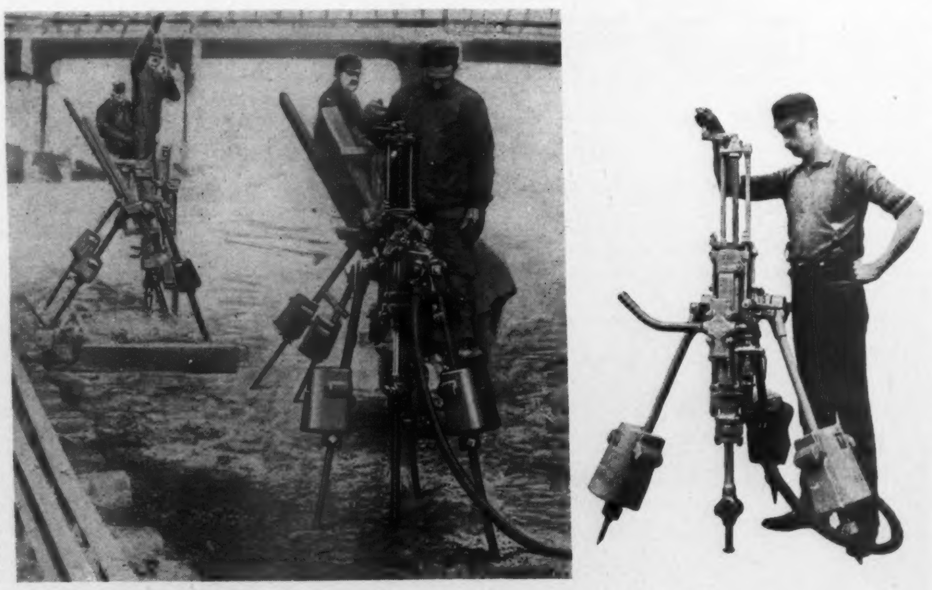
In 1851, also, the Cavé drill was patented in Europe. It was designed to be operated by either compressed air or steam. The drill steel was clamped directly to the piston rod, but the valve motion and rotation were controlled by hand and were, consequently, uncertain and slow.

When it was finally decided, in 1856, to drive the Hoosac Tunnel in Massachusetts, the rock was found to be very hard and difficult to drill with the then prevailing hand method. John W. Brooks, Stephen F. Gates, and Charles Burleigh built a drill for this work and obtained a United States patent on it in 1866; and Burleigh secured several other patents in the same year. About 40 drills, representing a modification of the Couch and Fowle patents, were constructed and used for driving the tunnel; but the expense of upkeep and handling was enormous. Burleigh redesigned the drill in 1868; organized the Burleigh Rock Drill Company; and bought the Fowle patent, which his machine infringed. With the new drills the Hoosac Tunnel was finished in 1873. It should also be noted, incidentally, that nitroglycerine, which had been patented in the United States in 1867 by its discoverer, Alfred Nobel, had its first application in that tunnel. It was manufactured by George W. Mowbray at North Adams, Mass. The construction of the Burleigh drill remained substantially unchanged up to 1872. In the meantime, however, a considerable number of them was built—in fact, "Burleigh" came to be the popular name for a piston drill among hard-rock men and persisted for many years after that drill was out of production.

In 1871, Simon Ingersoll obtained a United States patent on a rock drill and a universal tripod mounting. The latter appliance was an important step forward in rock drilling. The Ingersoll Rock Drill Company was formed to put his invention on the market; but as the Fowle and Burleigh patents stood in the way, the Burleigh Rock Drill Company was absorbed and the drill finally redesigned as the "Ingersoll Eclipse," which many rock-drill men of today still remember.

Simon Ingersoll took some part in developing and building the drill, as later patents show, but his official record terminates in 1877. Fowle and Burleigh also disappeared from the rock-drill field and evidently became interested in other endeavors. Henry C. Sergeant improved on Burleigh's tappet-valve motion and was the inventor of the "Eclipse" valve motion which he assigned to the Ingersoll Rock Drill Company. That was a distinct departure from the Fowle and Burleigh cam or tappet-valve motion which had given considerable trouble in the earlier drills. The "Eclipse" was an unbalanced spool valve, positively pressure thrown by the steam or air used to operate the drill, and had no metallic connection with the piston.

The Rand Drill Company started in business about 1873, and built rock drills after patents issued to J. R. Reynolds, M. Stannard, Joseph C. Githens, G. E. Nutting, and A. C. Rand. The Rand drill was a tappet-type machine, an improvement on the Fowle and Burleigh construction. The field was then open, as the Fowle patent protection had expired in 1868. Later on, in 1884, came the steam-thrown valve, invented by F. A. Halsey, which gave customers a choice between two drills of different designs. The Sullivan Machinery Company about this same general time manufactured a percussion rock drill ac-



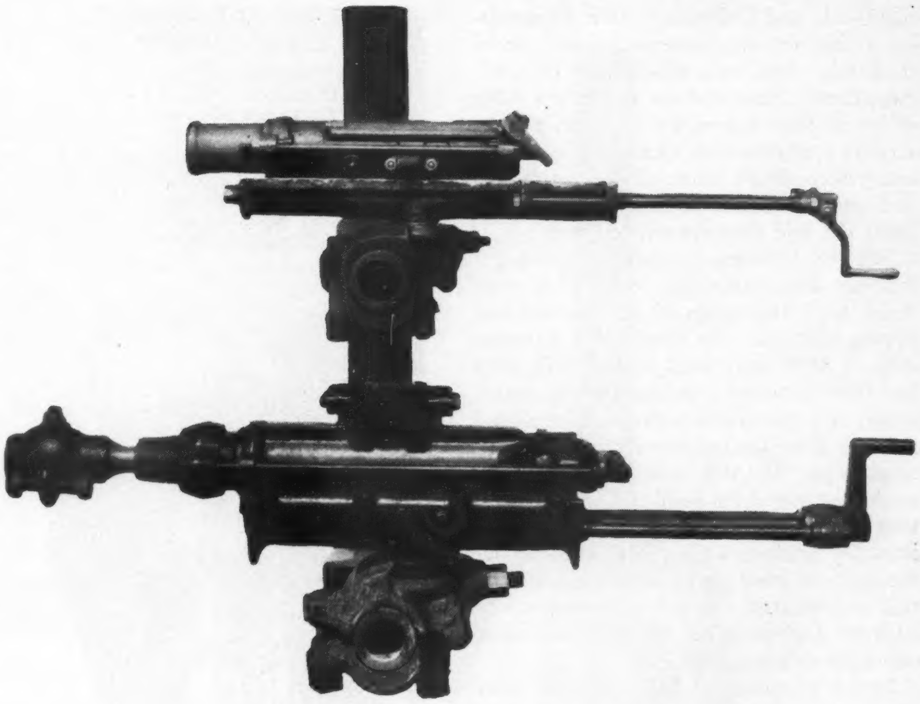
TRIPOD-MOUNTED DRILLS

Simon Ingersoll invented the tripod mounting in 1871, and it was extensively used for 40 years thereafter. Heavy weights on each of the legs kept the drill steady. Sometimes the operator stood on the tripod or took things easier in an improvised seat. The picture at the left was taken while excavating at the site of the Grand Central Station in New York City in 1912.

cording to Albert Ball's patent. This had a differential spool-valve motion, pressure thrown; but had all the other characteristic features of the piston drill.

In 1884, Sergeant formed the Sergeant Drill Company to make and to sell the Sergeant auxiliary-valve drill. That was a piston drill with the segment of a ring in contact with the piston acting as a trigger for moving the main valve. This company was an offshoot of the Sergeant & Cullingworth Company, which had developed and built drills and other machinery for the Ingersoll Rock Drill Company. The old Croton Aqueduct Tunnel, on which about 400 drills were in service, was driven during this general period. The Ingersoll Rock Drill Company and Sergeant Drill Company were consolidated in 1886 under the name of Ingersoll-Sergeant Drill Company, which continued to manufacture the "Eclipse" and Sergeant drills under Mr. Sergeant's personal supervision.

The McKiernan Drill Company, about 1892, built rock drills after the patent of Warren Wood. These machines were a slight modification of the "Eclipse" type. We find the names of John Pengilly, T. E. Sturtevant, S. G. McKiernan among those that contributed to the developments. Other individual manufacturers were in business only a comparatively short while and did little to influence drill progress, largely copying one or the other sucessful make with the exception of a few alterations mostly in valve motion.



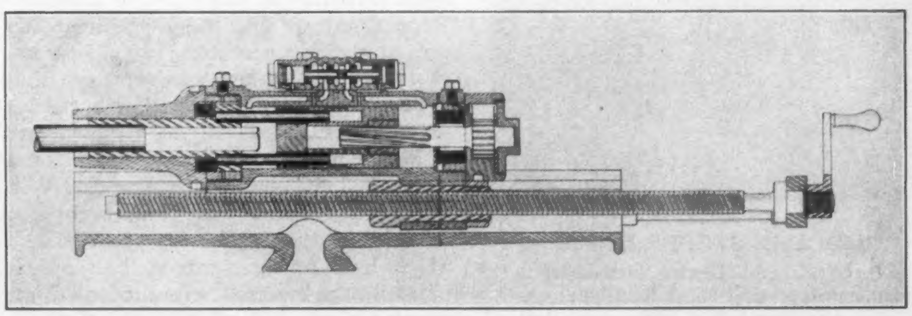
DRILLS OF TWO ERAS COMPARED

This picture graphically illustrates the progress that has been made in reducing the size and weight of drifter drills. The lower machine is an F-24 Sergeant piston drill which was a leader for many years and which was manufactured until about 25 years ago. The drill weighed 400 pounds and the column clamp 75 pounds. The upper drill is an N-75 drifter, the type that was used in driving the 56-foot-diameter diversion tunnels at Boulder Dam. It weighs 138 pounds and its column clamp 41 pounds. The respective total weights are 475 pounds and 179 pounds, despite the fact that both drills are of 3½-inch bore. In addition to the advantages of smaller size and lighter weight, the N-75 greatly outdrills the older machine and consumes far less air.

It should be remembered that until about 1900 most rock drilling was done with the piston type of machine in which the steel was fastened to the piston. Both piston and steel reciprocated, setting up in the hole a pumping action which, when water was added, served to expel the cuttings or to hold them in suspension as mud so that the hole could be cleaned by a sand pump or blower pipe. Holes pointing below the horizontal were drilled wet, and those pointing up or above the horizontal were drilled dry. In the latter case the cuttings fell out by gravity. This led to experiments with a light hammer-type of drill for up-hole work. In the hammer drill the steel is not attached rigidly to the piston, but is loosely held in a chuck while being struck by a piston or hammer that shuttles back and forth in the cylinder. The steel is rotated between blows by means of a rifle bar, a ratchet, and pawls, as in piston drills.

The hammer principle had been applied to small pneumatic tools such as riveting and chipping hammers for some years before it was used in connection with rock drills. The reason for this was that no means had been provided for removing the cuttings from holes other than those inclined high enough above the horizontal to permit gravity to perform that function.

Taking his cue from the smaller tools, C. H. Shaw, a Denver machinist, introduced hammer drills for stoping work some time before 1890. The particular merit of his drill lay in the inclusion at the bottom of the machine of an air-cylinder feed to hold the drill in position and to feed the steel into the hole. Shaw's drill soon acquired the popular name of "stoper," as it was first employed for overhead drilling in western mining districts, particularly in



BIRTHPLACE OF HAMMER DRILL

At the left is a picture of J. George Leyner's Denver machine shop as it appeared in 1891. Although Leyner did not secure a patent on the design on which all rock-drill construction until 1897 was fundamentally based, he was producing drills that embodied his improvements before that time. Leyner has been credited with inventing the hammer drill, but the records show that Sergeant obtained a patent on that feature in 1884. It is also known that C. H. Shaw built hammer-type stoping drills prior to 1890. However, Leyner made the hammer drill practicable by originating hollow drill steel which allowed water or air or both to be introduced into the drill hole to flush out the cuttings. The story of the great difficulties encountered in developing a satisfactory method of producing hollow steel was told in our April, 1936, issue. The drawing shows a section of the Leyner drill of 1896.

California and Colorado. As it represented a distinct improvement, this type of drill was soon in considerable demand. Apparently, Shaw did not realize the value of his air-feed device, for he failed to protect its application to rock drills by a patent. Accordingly, most of the piston-drill and pneumatic-tool builders of the day entered the field thus opened to them.

In 1890, J. George Leyner was running a machine shop in Denver and was in close touch with the needs of the surrounding mining district. He patented a hammer drill in 1897 that used hollow drill steel and thus furnished a means whereby water or air, or a mixture of both, could be passed through it for the purpose of expelling cuttings from the drill hole. That feature made hammer drills applicable for the first time to the drilling of holes directed horizontally or downward. The water going through the steel also eliminated the dust that represented a problem in connection with dry drilling with piston drills and hammer-type stoping drills.

Leyner's hammer drill therefore constituted a radical departure. At the time it was devised, no hollow drill steel existed; and as such steel was absolutely essential to the success of this type of drill, many different makeshifts were resorted to in order to produce it. Finally, demand created a process for rolling hollow drill steel. The development of the hammer drill and of hollow drill steel can thus be attributed principally to Leyner's persistence and to the progress that was made with makeshift steel. The records show that Sergeant got a patent on a hammer-type drill in 1884; but as hollow drill steel was then unknown, the hammer principle was evidently discarded as a failure. It was, however, the forerunner of the "Little Jap" drill, a hand-held sinker that Sergeant afterward developed.

In 1906, the Ingersoll-Sergeant Drill Company and the Rand Drill Company consolidated under the name of Ingersoll-Rand Company and began the manufacture of the products of the two companies. It turned out a high-speed piston drill, light and fast running, with a butterfly-valve motion. In 1912 the J. G. Leyner Company was absorbed by Ingersoll-Rand Company, and the Leyner-Ingersoll drill was put on the market. This move also resulted in the hand-held "Jackhamer" which had, to some extent, been anticipated by the Ingersoll-Sergeant Drill Company's hammer drill called the "Little Jap." The latter also had been instrumental in creating a demand for hollow steel.

Contemporaneously with Leyner, about the year 1900, D. S. Waugh, of Denver, obtained several patents on stoping drills of the hammer type that had been introduced by Shaw, with whom he had been associated. The manufacture of those tools was begun by the Denver Rock Drill Company, predecessor of the present Gardner-Denver Company.

The Cleveland Pneumatic Tool Company, which had started as a maker of riveting and chipping hammers under patents of Charles T. Smith, A. J. Johnson, and C. B. Richards, also set out to compete for the stoping-drill business. That was likewise the case with the Chicago Pneumatic Tool Company, which made its tools under patents issued to George H. Brown, Thomas Barrow, and Joseph Boyer. This company had entered the piston-drill business after the fundamental patents had expired. Following the expiration of the Leyner patent in 1914, all these concerns started to produce machines of the hammer type, so that, within the course of a few years, the piston rock drill was superseded.

William L. Saunders in April, 1889, said: "The rock drill embodies more inventions for its volume and weight than any other machine of equal importance." And, having examined all the patent data, we agree with him, although in 1889 the game had only begun. The rock drill is purely an American product. We can find no outstanding design or improvement that originated in any other country, and drills made elsewhere are largely copies of American machines. When a French commission visited the United States to investigate machinery for digging the Panama Canal, it selected the "Eclipse" drill of the Ingersoll Rock Drill Company, and that design has influenced all European drills.

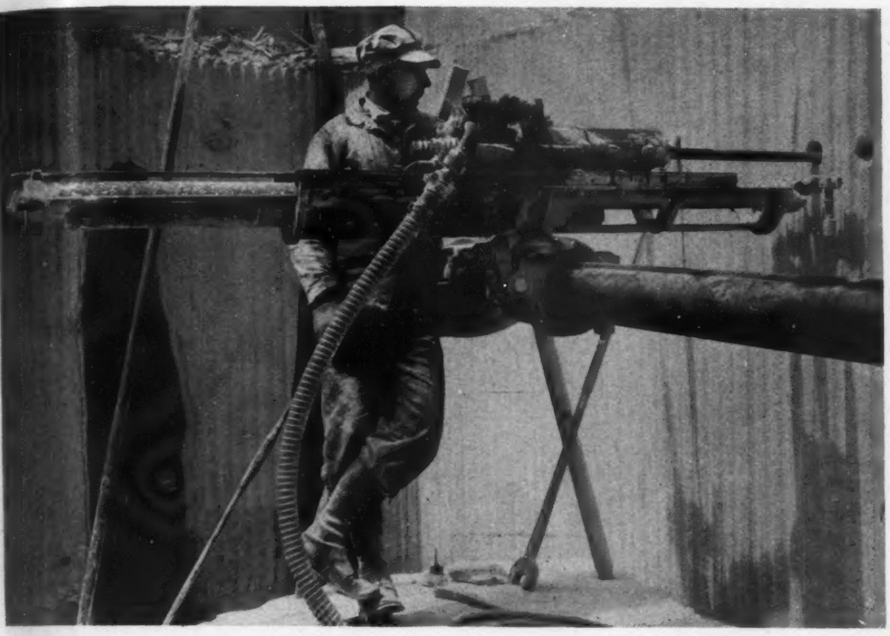
The rock drill created a large demand for air compressors, and thereby stimulated the development of these machines. With effective compressors available, air-driven tools of various sorts appeared for different industrial applications. Nearly all drill-manufacturing companies took steps to supply them and to make special machines

MODERN STOPER DRILL

C. H. Shaw of Denver introduced a hammer-type drill for drilling holes upward sometime before 1890. Solid drill steel could be used in that work, as the cuttings fell from the hole by gravity. Shaw's greatest contribution was the invention of the air-cylinder feed at the bottom of the drill to keep the tool in position and to feed the steel into the drill hole. Although it has been improved since then, the feed on modern stoping drills works on Shaw's principle.

FIRST AND RECENT JACKHAMER

Below is pictured the first self-rotating hand-held hammer drill, the forerunner of the new JA-30 drill shown at the right. It will be noticed that the original tool was bulky and cumbersome and required two men to operate it. The JA-30, by contrast, weighs only 30 pounds and is but 19½ inches long. More powerful Jackhamers of the same design are also made in the 45- and 55-pound-weight classifications.



MODERN DRIFTER DRILLS

Recent developments in drifter-type drills include improvements in the drills themselves and in the manner of mounting them for various applications. The automatic feed (above), which harnesses the natural tendency of the drill to creep forward, increases drilling speed and lightens the operator's labor. Wagon mountings (right) are now equipped with pneumatic-tired wheels for easy portability, have air-motor control of the feeding pressure, and can be quickly adjusted for drilling holes at any angle between straight downward and horizontal.

for mining coal, for quarrying building stone, and for handling materials. Thus the industry that sprang from rock drills began to assume large proportions, with extensive manufacturing facilities and large staffs of specialists who were engaged to extend and to improve the products.

It should be mentioned that it has been possible in the foregoing only to approximate the time the different rock drills went into production. After a patent has been applied for, it sometimes takes from two to five years before it is granted; and it may be that production in some instances was started prior to the patent dates. Furthermore, some inventions may have been omitted, as assignment is not always given.

The three men that contributed most to the development of the rock drill and allied products were undoubtedly Sergeant, Shaw, and Leyner. When the Ingersoll Rock Drill Company and the Sergeant Drill Company consolidated under the name of Ingersoll-Sergeant Drill Company, the following public statement was made: "Mr. Henry C. Sergeant has had an experience of 20 years in designing rock drills. He was the first to perfect the tappet drill; the first to apply the steam valve to a rock drill; and is the inventor of what is known in Europe as the Eclipse drill and in America as the Ingersoll Eclipse drill. His last production, the Sergeant drill, contains many valuable improvements, the direct result of experience." And the patent data confirm this statement.

Shaw invented the air feed for the stoper drill—the forerunner of the hammer drill. Leyner invented the water-fed hammer drill, popularly called the "Water Leyner," a distinct and radical departure from previous practice. Through his persistence hollow drill steel became a commercial product. When his patent expired in 1914, the field was open to all builders; and hammer drills, because of their increased drilling speed and consequent savings in cost, have practically superseded piston drills.

The patent records show that, starting with the Burleigh Rock Drill Company in 1866, its successors—Ingersoll Rock Drill Company, Ingersoll-Sergeant Drill Company, and Ingersoll-Rand Company—were the owners, successively, of all fundamental patents on piston rock drills. By acquiring the Leyner patents, in 1912, the last-named concern also brought the hammer rock drill—"Water Leyner"—to commercial application.

Since the original Leyner patent expired, 23 years ago, innumerable patents have been taken out for improvements on his design. So far, no radical changes are apparent. Increased drilling speed, reduced air consumption, greater ease of handling, and longer effective service life are the most notable results of the advances that have been made.

Hollow drill steel has been so improved that drilling speed can be increased without too quickly destroying the steel; and research in this direction has been continuous and active. The detachable bit, introduced less than ten years ago, is solving the problem of forging the drilling end, and brings this treatment down to a controlled mechanical operation. The shank end of the steel and the means of coupling the drill rod have not been fundamentally changed so far.

In consequence of the development of special mountings for different kinds of work and of devices for feeding drills automatically, operators can do more drilling with less fatigue. On the 56-foot-diameter Boulder Dam diversion tunnels, as many as 30 drills, all working simultaneously, were mounted on a "jumbo" or carriage.

Because of the lighter and faster drilling machine of the hammer type, rock can now be drilled so much cheaper than formerly that lower-grade ore can be mined at a profit. For that matter, all undertakings of which rock removal is a part are getting the benefit of the greater and more economical footage that it is possible to obtain with that drill.

The foregoing record shows that the piston-type of rock drill had a life of about 65 years—that is, from 1849 to 1914, when it was supplanted almost entirely by the hammer drill. Starting with the Leyner patent in 1897, the hammer drill is now 40 years old and, like the piston drill, is greatly improved in detail, although the original principle of construction remains essentially unchanged. This brings rock-drilling-machine history up to date.

Bottling Up an Underground Fire

William S. Powell

AN UNDERGROUND fire, that has been burning continuously since 1884 near Shawnee and New Straitsville in southeastern Ohio, is about to be curbed. It has already consumed more than 28,000,000 tons of high-grade coal, and might, if let alone, destroy an additional 14,000,000 tons. And, what is more, the conflagration has even threatened to spread to the very heart of the Hocking Valley Coal Field which normally supplies about one-tenth of the nation's coal.

The area now affected measures approximately 4x6 miles. The line of the blaze follows the irregular outcrop of the coal bed, which is more than 30 miles long. In some places the fire is visible, but much of it is hidden beneath the rocks that overlie the coal. The plan is to isolate the burning area by the construction of underground barriers that will prevent the fire from eating its way along the coal bed to the surrounding sections. After it has been thus confined, steps will very likely be taken to put it out. Work on the isolation scheme was started on October 1, 1936, at which time it was expected that approximately eighteen months would be required to complete it.

Numerous efforts have been made either to extinguish the fire or to prevent its spread; but so far all have been unsuccessful. On one occasion, a small creek was diverted so that it would flow into one of the abandoned mine shafts. The water, on coming in contact with the burning coal, generated steam, and the pressure built up served to force combustible gases through the coal seam, thereby spreading instead of checking the conflagration. At another time, concrete walls were built in its path at several locations, but the heat cracked them and the fire passed through. The work

DESOLATION WROUGHT BY FIRE

The present appearance of 35 acres of land on Hazelton's Hill near New Straitsville. Huge holes, formed by caving in of the ground overlying the burning coal, emit smoke, gas, steam, and flames. The land has been rendered worthless for farming; but the oil well seen in the background has thus far escaped damage.

MINE RESCUE TEAM

Because of the hazardous nature of the work, two mine rescue groups have been organized and trained for emergency service. Members must be between 21 and 45 years old and physically sound. Each wears an oxygen mask and carries a tank containing 270 quarts of compressed oxygen, sufficient to sustain life for two hours while working strenuously or for from eight to twelve hours while under no physical exertion. When fully equipped, each man carries 40 pounds. The masks prevent conversation, so the men communicate by signaling with the rope which each grasps in his right hand. The truck that is maintained for transporting the crews carries a reserve supply of oxygen as well as pumps for refilling the individual tanks. The rescue crews were trained by R. C. Ridley, of the U. S. Bureau of Mines, and by his successor, Robert Eaton, safety engineer on the project.

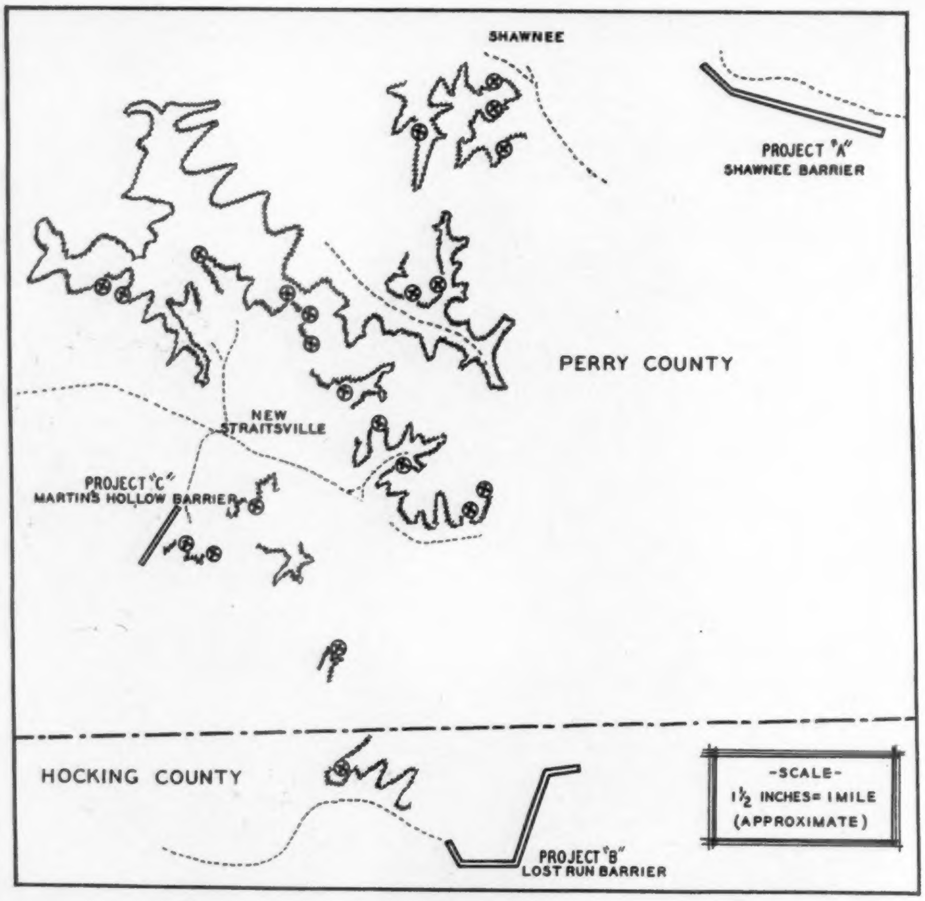
now underway will similarly make use of barriers; but they will be composed of earth and mud instead of concrete, and it is believed that these materials will be effectual.

The plan being followed was suggested by technologists of the U. S. Bureau of Mines after they had made a survey of the area. The region consists of rolling country, and the coal bed, which rests in a generally horizontal position, extends through the higher hills and outcrops on either side of each intervening valley. The survey disclosed that the coal within the burning zone is continuously connected with that in the surrounding area at only three points, and it is at these locations that the barriers are to be placed. The openings that will be required for the barriers will be excavated by a combination of trenching and tunneling, the latter method to be employed wherever the coal lies at a greater depth than 30 feet below the surface.

An accompanying map shows the sites and general outlines of the openings. Two of them are in Perry County and one is in

A MINE ENTRY AFIRE

A recent outbreak in the Lanning Mine entry near New Straitsville. The owners had just started developing 40 acres of what they thought was solid coal. One morning when they came to work they found the interior of the adit ablaze and flames leaping 20 feet into the air from the opening.



AREA TO BE ISOLATED

Barriers of earth and mud will be built at three points, the only places where the coal seam extends beyond the fire zone. The openings for the barriers will consist in each case of two open cuts, one at either end, linked by a tunnel. The wavy lines indicate outcropping coal beds over which the fire has passed: the circles containing crosses mark the locations of fires that are known to be active. Just how much of the deeper-lying coal beds is on fire is not known.

Hocking County. Project "A," in the northeastern part of the burning area, will involve the digging of approximately 3,800 feet of tunnel and 1,500 feet of open cut. Project "B," at the southern edge, will call for 2,500 feet of tunnel and 1,200 feet of open cut. Project "C," on the eastern side of the fire zone, will be about 400 feet long and consist mostly of tunnel.

The coal seam varies from 3 to 4 feet in thickness. It is underlain by fireclay and overlain by a carbonaceous shale that is partially combustible. Above this, and reaching nearly to the ground surface, is sandstone. The open-cut sections, which will be about 16 feet wide, will, of course, extend through all the overlying material to the bottom of the coal. In the tunnel sections, all the coal will be removed, together with as much of the overlying carbonaceous shale as is deemed necessary to make certain that all the material that could possibly burn has been taken out. In most cases the tunnel roof will be from 4 to 6 feet above the top of the coal.

Three gasoline-engine-driven shovels are being used on the open-cut work, one at each end of Project "A" and one at the eastern end of Project "B." Excavated material is loaded into tractor-drawn wagons for removal. Picks and shovels and wheelbarrows supplement this mechanical equipment. The tunnel sections that are to be 12 feet wide and of varying height will be drilled and blasted. A portable air compressor will be employed at each of the three locations, and drilling will be done with hand-held drills. Initial work on this phase of the operations has been started at the western end of Project "B," where two JA-45 Jackhamers are in service.

The tunnels at Projects "A" and "B" will cut across old mine workings at several points. Where such openings are encountered, they will be sealed off to prevent the inflow of the mud that will later be introduced into the tunnels. It is almost certain that the tapping of these former workings will admit gas to the tunnels, and this will add to the problem of maintaining the air so that it will be sufficiently pure for the workers to breathe without harmful effects. Accordingly, provisions are being made to force ample quantities of fresh air into the bores from the outside by means of blowers and ducts.

Most of Project "C," and parts of the two others, will extend through sections where the coal has been taken out, except for pillars that were left to support the roof. In the many years that have elapsed since mining ceased, there has been much caving in between those pillars or stumps. None of the solid coal that remains will be removed for fear of opening up breaks in the ground surface. In avoiding these pillars it will be necessary to run the tunnels on zigzag courses rather than in straight lines.

It is known that considerable water will be encountered, particularly when old mine workings are tapped, and even though it will drain by gravity at some locations, still much pumping will be required. For this service have been purchased four 2RVH-15 Cameron Motorpumps which are driven by explosion-proof motors and equipped with bronze impellers and ends to resist the corrosive action of the waters which they will be called upon to handle. These same pumps may be used later for slushing mud into the tunnels, although details of the method by which this is to be done have not been worked out.

Wherever unstable ground is penetrated, the tunnels will have to be supported. For this purpose has been adopted a simple 3-piece type of timbering, consisting of two vertical side posts 8 feet long and a crossbar. The latter will be notched to assure uniform width. In the worst ground these sets will, it is believed, have to be placed so close that they will touch one another. Under more favorable conditions they will be spaced up to 3 feet apart. The sides will be lagged with 2-inch planks and the roof with 3-inch planks.

After the tunnels have been driven through, vertical 10-inch holes will be drilled down to them from the surface at intervals of from 50 to 100 feet. Through these the mud will be forced underground, probably with compressed air. The plan is to fill the tunnels by sections. By way of illustrating the procedure, let us assume that we are dealing with a stretch of tunnel in which the holes from the surface are 50 feet apart. First it will be necessary to remove the timbers for a distance of 25 feet on each side of the bottom of a hole and to construct bulkheads at both ends to form a 50-foot section. The mud will then be pumped into it from above. Additional sections will be similarly treated, one after the other, until the entire tunnel has been filled. By dividing each tunnel in this manner into a series of smaller compartments there will be far greater assurance that all the open spaces will be completely filled and that the mud will be forced into any cracks that may be in the side walls. The open-cut sections at both ends of the tunnels will be backfilled with earth.

Because of the presence of gas and of the general hazardous nature of the work, all possible safety precautions are being taken. Only experienced miners are being employed underground, and all are required to wear approved protective hats, shoes, boots, and goggles. Smoking and open flames are prohibited, and electric-battery cap lamps are used. A safety engineer

makes frequent inspections of the workings, and safety meetings attended by foremen and workmen are held twice monthly. Two 5-man mine rescue teams, whose members have been selected on the basis of physical fitness, have been trained for emergency service and furnished with approved equipment by the Bureau of Mines. A truck is maintained for their transportation, and they can reach any location where work is being carried on within one hour.

The undertaking is being financed by the Federal Government with a WPA grant of $365,000 for the dual purpose of unemployment relief and of conserving natural resources. In addition to the coal, there is oil and gas, limestone, iron ore, and fireclay in the region, and the commercial recovery of these would be rendered difficult, or perhaps impossible, if the fire were permitted to spread. South of the burning area many coal mines are in operation, and the products of some of these are shipped as far as the Pacific Northwest.

The curbing of this miniature inferno and, more especially, its subsequent extinction, would be greatly welcomed by the residents of the area. For many years they have been living virtually on top of a furnace that has already done great damage and that constitutes a constant threat to both lives and property. Some rather miraculous escapes from personal injury and even death have been recorded; and a few cases of unexplained disappearances of persons have lent a rather gruesome touch to the situation.

With the conflagration spreading underground in all directions, it is never known just where it will next break through the surface. Already, the flames and the gases emitted by them have ruined many acres of farm and timberlands. Numerous homes have had to be abandoned, and churches and schools have been threatened. Where the fire has passed, subsidence of the ground has usually followed, affecting buildings, highways, and farmlands. In one place near New Straitsville a crevice has been opened up across a hill for more than a mile.

About two years ago the blaze crept up to the outskirts of the town and undermined the foundations of more than a dozen homes, causing them to be deserted. It is now nearing the main street of the community. Again and again, workers in mines adjacent to the burning area have felt the walls of their drifts or rooms grow increasingly warm. From experience they know when the temperature reaches the danger point, and when that time arrives they gather up their tools and retreat, hurriedly pulling up the tracks as they go. Not long ago the pupils in a school began to complain about the heat in the building. Investigation disclosed that the fire had approached to within 20 feet of the structure.

During rainy or foggy weather, fumes from the smoldering coals creep under the doors of houses. At night the hillsides are illuminated so that they resemble the nether regions. Having become accustomed to the conditions, the residents do not take them nearly so seriously as do visitors who happen into the locality. They are even inclined to joke about the situation; and one of their choicest stories is that about the farmer who planted a field of potatoes and harvested a crop that was already baked.

New Straitsville was founded in 1870, and grew rapidly as a result of the coal-mining operations. The coal was of good grade, was above the general level of ground water, and was easily accessible by driving drifts at the numerous points of outcrop. By 1880 six companies were producing. In the following year the Columbus Hocking Coal & Iron Company purchased the holdings of five of those concerns, as well as several thousand acres of land south of New Straitsville on which there were coal and iron mines and blast furnaces. The company was commonly known as The Syndicate.

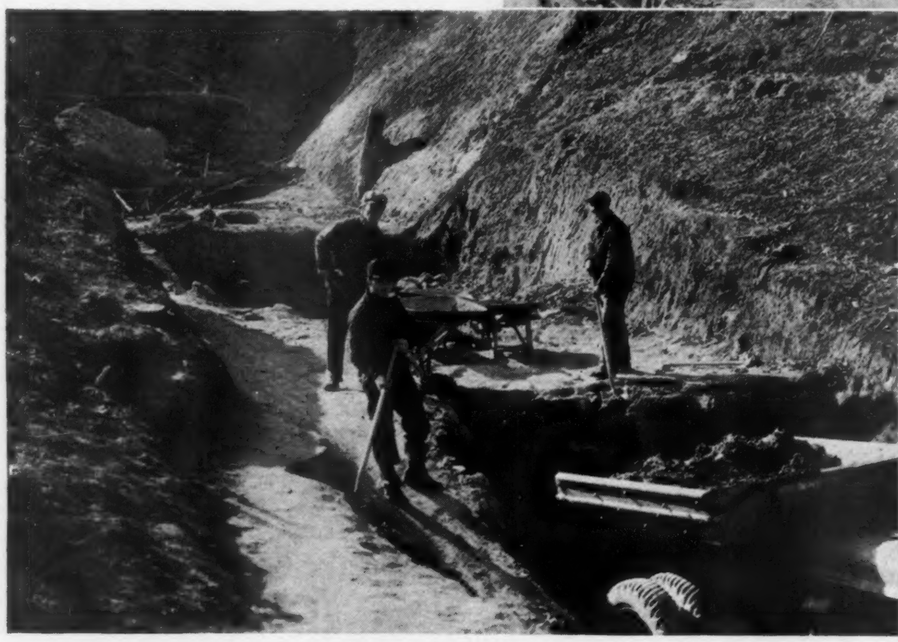
One morning in November, 1884, smoke was discovered issuing from an opening leading to its Lost Hollow Mine, which is adjacent to the site of Barrier "B." Within 24 hours the workings were in flames. These were fanned by drafts induced by the rush of air through the ventilating shafts that had been sunk to the coal measures from the ground surface. Efforts to extinguish the blaze were of no avail, and despite the sporadic attempts that have

WHERE HIGHWAYS HAVE SAGGED

The black areas in the highway shown above are patches made to fill up sections that had caved in as a result of the fire burning below. The fire has virtually surrounded a producing oil well which is equipped with three sets of tubing, one within the other, to keep the flames from reaching the oil. The picture at the left is of another stretch of road that has been affected by the fire, the smoke of which is visible in the distance.

WORKING SCENES

These pictures show early stages of the operations now being carried on to confine the fire to its present area. The top and central views are of WPA workers in open cuts leading to two of the tunnels. The bottom picture shows the portal of one of the bores that is being driven under land on which the trees have thus far escaped the effects of the flames.



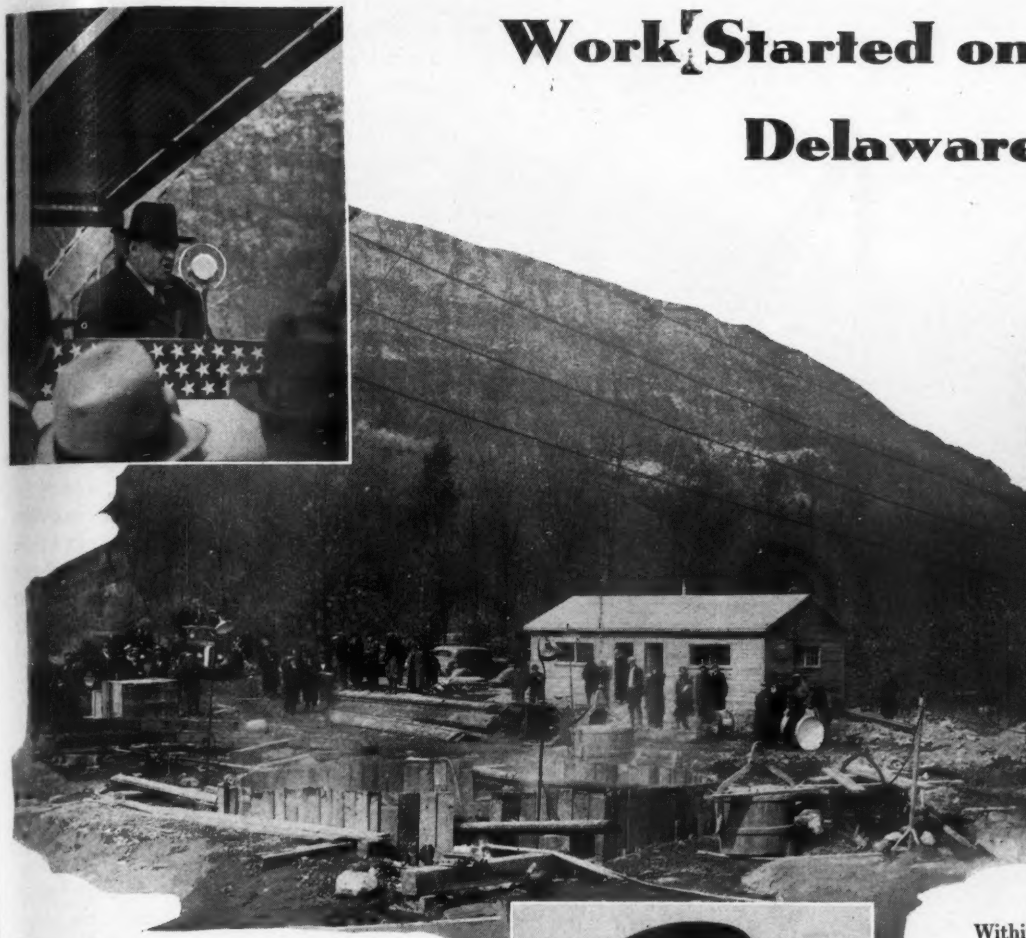
been made to curb the fire in the intervening years, it has steadily encroached upon new territory.

As principal operator in the district, the Columbus Hocking Coal & Iron Company persisted through the decades in its efforts to quell the fire, and also kept as many of its properties going as possible. Little headway was made, however; and as the area affected grew greater, the activities of the company had to be continually curtailed. Eventually, the concern found difficulty in meeting its tax payments, and could employ fewer and fewer people. In recent years most of the miners in New Straitsville and Shawnee have been compelled to seek work outside their immediate environments.

It is therefore not surprising that general business in the region has fallen off alarmingly and that businessmen have joined forces with the mine operators in an attempt to induce the Federal Government to take steps with a view to bringing the fire under control. Under the leadership of Adam J. Laverty, who had been a coalmine superintendent for some 40 years, the matter was brought to the attention of the congressman of that district, and he succeeded in securing a WPA allotment in December of 1935. The beginning of actual work was delayed, however, until last autumn.

Directing the operations and lending technical assistance are: W. J. Fene, chief engineer of the U. S. Bureau of Mines at Pittsburgh, Pa.; J. R. Cavanaugh of Elizabethtown, Pa., who is director and supervisor; Robert Eaton, safety engineer; and James Berry, superintendent of the Ohio Division of Mines. Mr. Laverty is general superintendent. All foremen and supervisors on the job have had experience as mine superintendents. The three phases of the project are giving employment to about 300 men.

Work Started on Delaware Aqueduct



THE SPEAKERS

In the squares, from left to right: Mayor F. H. LaGuardia delivering the principal address; Monsignor M. J. Lavelle, 85-year old prelate, who blessed the proceedings as he had done 30 years previously at the beginning of the Catskill Aqueduct; and George J. Gillespie, president of the New York Board of Water Supply, who presided.

THE FIRST SHOTS

Within a protective timber sheeting, driven to assist in the excavating of the top soil, four charges of dynamite were detonated by Mayor LaGuardia of New York City to signalize, formally, the beginning of a $273,000,000 project to increase the water supply of the nation's metropolis. Thus was started an undertaking the first two stages of which will perhaps require eleven years for their completion, with still a third to come at some time in the future. The first shots were well blanketed with a mat of timbers, so that the only visual effect was a shower of chips.

CONSTRUCTION of the new $273,000,000 Delaware Aqueduct of the New York City water-supply system was formally inaugurated on March 24, when Mayor Fiorello H. LaGuardia fired the first charges of explosives in Shaft No. 3, a short distance west of the Town of Gardiner, in Ulster County. The ceremonies were attended by more than 1,500 persons, including city officials, engineers, construction men, and residents of the surrounding region.

The exercises launched one of the largest construction projects ever undertaken—the driving of 85 miles of tunnel through solid rock to deliver water to New York City from one tributary of the Hudson River and from several branches of the headwaters of the Delaware River. It was described in our February, 1937, issue. In his address, Mayor LaGuardia called attention to the magnitude of the enterprise, and predicted that the works then being started would remain in service for centuries to come, just as some of the old Roman aqueducts are still in use today.

The exercises were presided over by George J. Gillespie, president of the New York Board of Water Supply, which agency has charge of the huge undertaking. Mr. Gillespie reviewed the history of the legal difficulties and other obstacles that had to be surmounted before the United States Supreme Court finally gave the city permission to develop a total of 440,000,000 gallons a day from the Delaware River watershed.

Speakers other than the Mayor included Harold F. Traband, representing Comptroller F. J. Taylor of New York City, who was unable to attend; Lithgow Osborne, chairman of the New York State Water, Power, and Control Commission; and Walter E. Spear, chief engineer of the Board of Water Supply. An interesting feature was the delivery of the invocation by the Rt. Rev. Monsignor M. J. Lavelle, vicar general of the Catholic Archdiocese of New York, who acted in a similar capacity at the time construction on the Catskill Aqueduct was begun 30 years ago.

The scene of the ceremonies was the Wallkill Valley, lying at the foot of the Shawangunk Mountains and approximately 13 miles from the head of the aqueduct line. Shaft No. 3 is one of three, aggregating 3,215 feet in depth, that will be sunk by the Dravo Construction Corporation of Pittsburgh, Pa., under a $1,738,250 contract awarded on January 22. These are among the deepest of a total of 30 shafts that will be excavated to provide access to the tunnel grade. Shaft 2A, which adjoins No. 3, will be the deepest of them all—1,550 feet. The three shafts in question will be circular, with a diameter of 14 feet inside their concrete lining.

CLEARING THE DECKS FOR ACTION

As the crowd thinned, and photographers packed their equipment, preparations were made for the sinking of Shaft No. 3, which will have an inside diameter of 14 feet and will be carried to a depth of 840 feet.

The Dravo Construction Corporation was also awarded a second contract for the sinking of ten shafts at the southerly end of the aqueduct at an expenditure of $4,108,583. That section of the tunnel will extend from Kensico Reservoir to Hill View Reservoir, and is being provided in order to safeguard the city against a water shortage in case of failure of the existing Catskill Aqueduct which connects the two reservoirs. It will also augment that part of the Catskill line that now carries approximately 60 per cent of the water consumed in the city and that is barely capable of handling peak demands.

The second feeder line from Kensico to Hill View long has been considered a vital need, as even a 1-day shutdown of the Catskill Aqueduct would have serious consequences. The ten shafts will range from 320 to 670 feet deep, with a combined depth of 4,700 feet. At three of the locations there will be two shafts, spaced from 50 to 135 feet apart. One of these will serve as an uptake and the other as a downtake, with connections on the surface. Their diameters, inside the concrete linings, will range from 15 to 19½ feet. The Dravo Corporation has already assembled considerable plant and equipment at the various shaft sites and will soon have operations actively underway at the respective points. The time limit for completing the three shafts at the upper end of the line, where the most extensive work has to be done, is 24 months.

Shafts Nos. 4, 5, 5A, and 6, adjoining the Dravo contract on the south, will be built by the Frazier-Davis Construction Company of St. Louis, Mo., under a $2,294,415 contract. The first three will be 14 feet in finished diameter, while No. 6, which will serve first for construction and later for drainage, will be 26½ feet in diameter.

The W. E. Callahan Construction Company of Dallas, Tex., has been awarded a $1,926,150 contract for Shafts Nos. 7, 8, and 9. The last named will be double, consisting of an uptake and a downtake. Three of the shafts will be 14 feet in finished diameter and the fourth will be 15 feet. Both the Frazier-Davis and Callahan concerns are building roads, erecting structures and otherwise making preparations to start actual excavating.

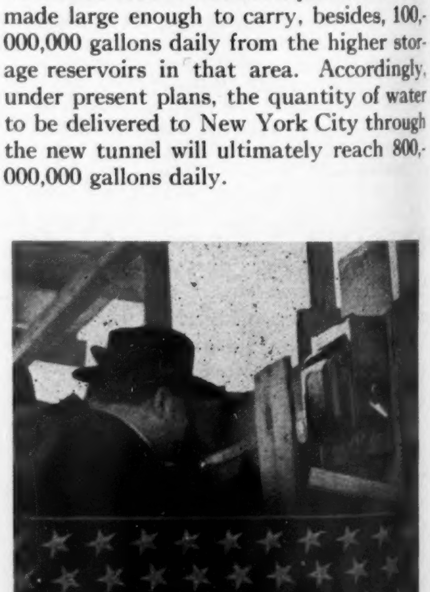
The rock that will be encountered in the sinking of the 21 shafts that have been contracted for thus far will vary widely, according to the locations. At the upper end of the line it consists principally of sandstones, shales, slates, and some grit. Farther to the south, on the Callahan contract, gneiss predominates, with granite and schist also occurring. At the south end, the material to be penetrated is gneiss and schist, with occasional granite intrusions Although methods of procedure have not yet been worked out, it is expected that most of the drilling will be done with hand-held drills of medium weight. Where exceptionally hard rock is met, heavier sinking drills will probably be used. When work gets underway on all 30 shafts, several hundred drills will be in service.

All the contracts call for sinking the shafts to tunnel grade and for lining them, as well as for driving approximately 200 feet of tunnel in each direction from the respective shaft bottoms. In cases where powder magazines on the surface would be hazardous, the shaft contractors will also excavate underground spaces for the storage of explosives. Contracts for driving and for lining the tunnel, itself, will be let sometime in the future.

Provisions for financing the shaft-sinking was made in the 1936 budget of New York City with an item of $20,000,000. Of that sum $17,500,000 was appropriated during the year by the Board of Estimate and Apportionment. In submitting his budget recommendations for 1937, Mayor LaGuardia included an additional $117,315,000 for the Delaware Aqueduct construction, with the explanation that it would be spent within the next five years at the rate of $20,000,000 to $25,000,000 annually.

The indications are that it will take approximately seven years to complete the first stage of the development, which includes the 85-mile aqueduct and reservoirs to impound the waters of Roundout Creek and the Neversink River. Extension of the system to the East Branch of the Delaware River, as contemplated in the second stage of the development, will most likely get underway before the first stage is finished and the expectations are that it will be completed about 1948.

The first stage will, it is calculated, make available a sustained daily water supply of 170,000,000 gallons. The second stage will add 370,000,000 gallons, bringing the total to 540,000,000 gallons. Further development of the system—extending the line so it will tap three other streams in the Delaware watershed—would increase the daily supply by 160,000,000 gallons, or the total to be carried through the aqueduct to 700,000,000 gallons a day. From the Croton watershed southward, the aqueduct will be made large enough to carry, besides, 100,000,000 gallons daily from the higher storage reservoirs in that area. Accordingly, under present plans, the quantity of water to be delivered to New York City through the new tunnel will ultimately reach 800,000,000 gallons daily.



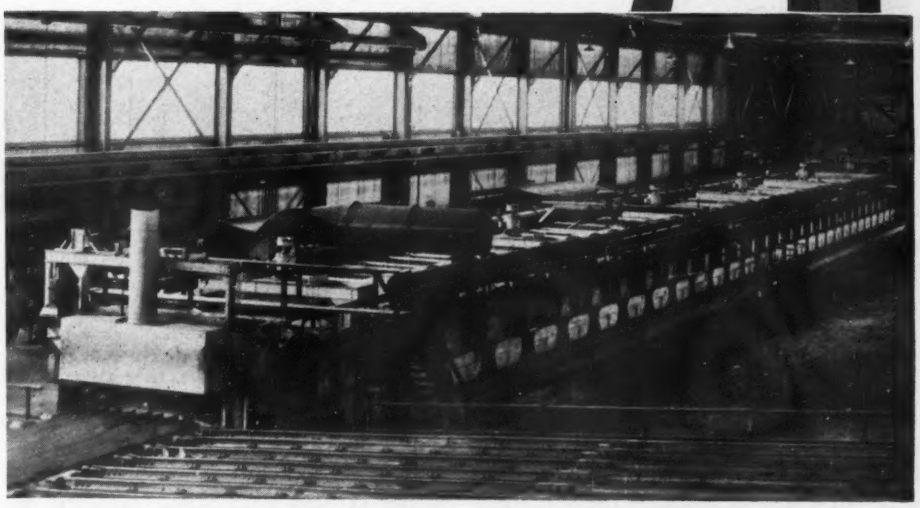
PUZZLED

Mayor LaGuardia approaches the blasting switch a little cautiously, wondering how it works. A brief course of instruction followed; the padlock was removed; and an instant later the stillness was broken by the first blast on one of the largest construction projects ever undertaken.

New Heat Treatment Improves Steel Rails

A NEW process of heat-treating railroad rails was introduced recently at the Gary, Ind., works of the Carnegie-Illinois Steel Corporation, a subsidiary of the United States Steel Corporation. It is known as Brunorizing, and results in rails having a finer grain structure and therefore greater toughness, ductility, and resistance to breakage than those made in the customary way.

Brunorizing includes the principles of normalizing, which consists of heating steel to a point above its critical temperature and then cooling it in air. One of the final steps in the new treatment is the hardening of the ends by quenching them with blasts of compressed air. In effect, the process is a return to the fundamentals of the metallurgy of steel. For some years it has been the tendency to alloy other elements with steel so as to impart certain physical properties to given products. But all the while was overlooked, more or less, the fact that one of steel's inherent characteristics is to react differently to variations in heat treatment. Research to date in connection with Brunorizing indicates that many of the properties that were thought to be the result solely of alloys can be obtained by altering conventional methods of heat treating.



BRUNORIZING FURNACE

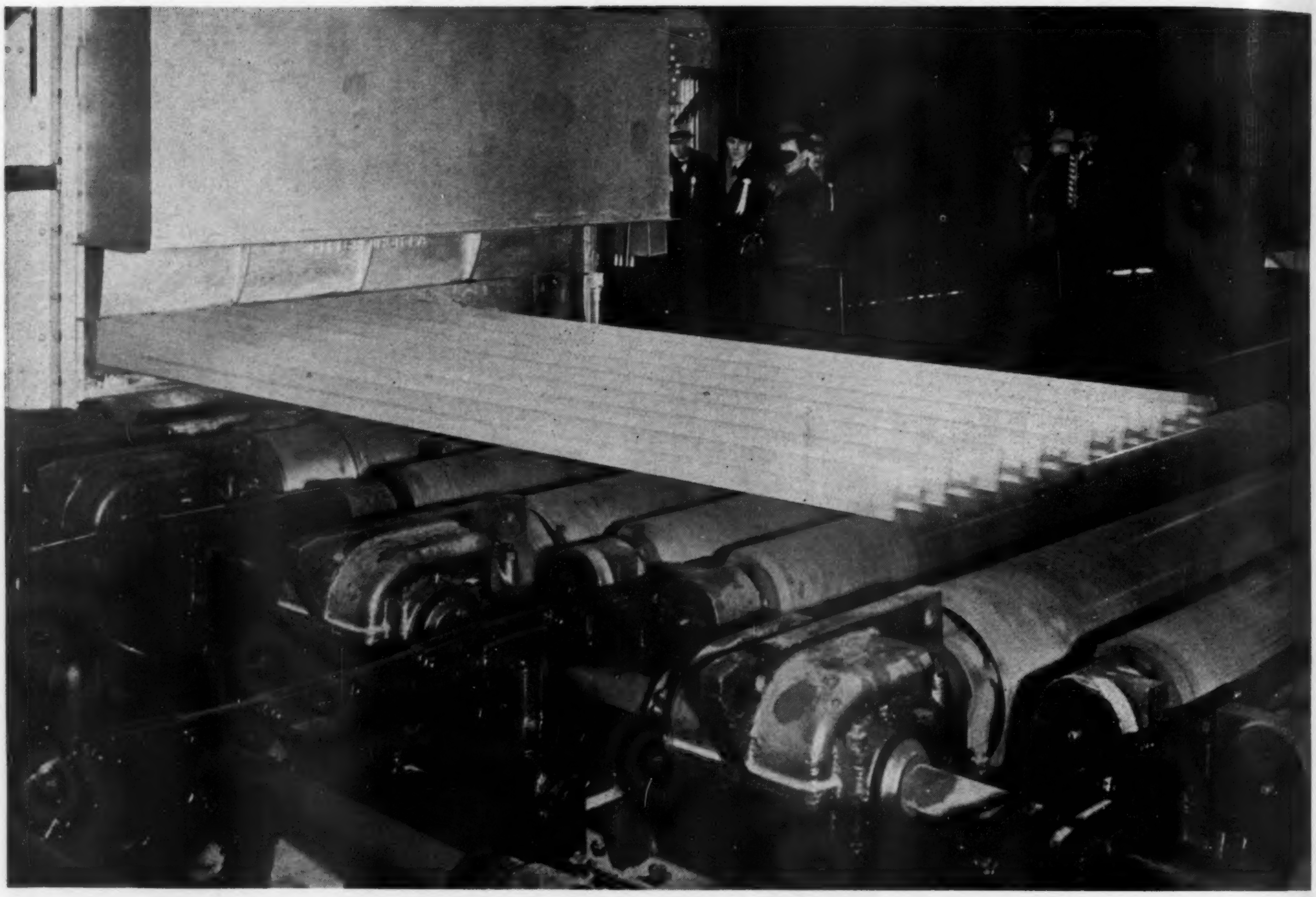
Railroad rails come from the finishing rolls at a temperature of between 1,750° and 1,900°F. After they have cooled to about 1,100° they are placed in a gas-fired furnace and reheated to around 1,525° or 1,550° under close temperature control. This heat treatment, termed Brunorizing, insures a fine grain structure which, in turn, increases ductility to a marked extent. Evidence of this is had in the upper picture, which shows a Brunorized rail that has been twisted through three complete turns without fracturing. A rail cooled by the usual process broke after being given one complete turn.

The advantages claimed for the new process are fivefold: First, the grains of which the steel is composed are finer; second, the stresses in the rails are lessened; third, the toughness is increased; fourth, conditions are set up which make possible uniform end hardening; fifth, the rails are much more ductile than those cooled by the ordinary hot-bed process.

In the case of ordinary cooling directly after hot rolling, the rails are delivered from the rolling mill to large grids which are known as hot beds. There, while still at red heat, they are spaced a few inches apart and allowed to cool from the final rolling heat—which may be anywhere within the range of 1,750° to 1,900°F.—to atmospheric temperatures without definite control of the rate of cooling. In Brunorizing, on the other hand, the rails are reheated after they have reached a temperature of from 900° to 1,100°F.—that is, they are transferred from the cooling bed to a roller table, are spaced evenly, and then delivered to the reheating or Brunorizing furnace.

This is a gas-fired furnace designed for continuous reheating, and is probably the largest of its type ever constructed. It is 9½ feet in width inside, 252 feet long, and holds at one time six groups of eight 39-foot rails. The rails, resting on their sides, are carried lengthwise through the furnace by means of special alloy-iron, heat-resisting rollers.

As the reheating time varies between 18 and 30 minutes, depending upon the rail section, new groups of rails enter the furnace at regular intervals of three to five minutes. When a new one arrives, all six groups already in the furnace advance a rail length, with the foremost set of eight leaving the furnace. In the interval between charges, the rails are continually moved to and fro several times a minute and through a distance of 2 feet by the rollers. This assures more uniform heating and lessens any tendency of the rollers to sag at the operating temperature.



EMERGING FROM THE FURNACE

An observer, at the right, is checking the temperature of eight rails as they come from the reheating chamber. Immediately after leaving the furnace, the ends of the rails are quenched by subjecting them to blasts of compressed air at 125 to 150 pounds pressure. This treatment increases the hardness of the metal at those points. The air is furnished by a 3,000-cfm., 2-stage compressor driven by a 700-hp. direct-connected synchronous motor. As the air requirement varies from time to time according to the number of rails in a lot, their cross section, and the end hardness specified, provision is made for discharging any surplus into the central, plant supply line.

The furnace is divided into eight zones for automatic heat control, and is equipped with large fans to circulate the contained gases and, further, to bring about more uniform heating. Each zone is provided with the most modern facilities for controlling the quantities and the proportions of coke-oven gas and air necessary for both proper combustion and proper furnace atmosphere. Recording pyrometers are connected with the temperature controls of each zone. The operating temperatures and the temperature of the rails coming out of the furnace are checked also by observers using optical pyrometers. The rails are heated uniformly throughout their full length when about halfway through the furnace—the other half of the furnace treatment being given over to thorough equalization. From the furnace the rails pass on to an adjoining roller table.

Most orders for Brunorized rails specify that the ends shall be hardened at the mill. In the Brunorizing process the normalizing and end-hardening operations may be combined—the ends of the hot rails being quenched with air blasts immediately following their discharge from the furnace. The roller table which receives the rails is equipped with an ingenious arrangement of manipulators for aligning the rails with groups of quenching nozzles at each end of the table. When the rails have been properly spaced, a swinging motion of the air-nozzle carriage brings the nozzles up so that they firmly engage the ends of the rails. A centrally disposed valve, operated by an electric switch, is opened, and jets of compressed air are directed against those surfaces for a predetermined time.

The duration of the quenching treatment is controlled by an electrical timing device which automatically closes the air valve at the right time. The air pressure used for this purpose varies between 125 and 150 pounds per square inch, and the time required to do the work ranges from 1½ to 2½ minutes, both being regulated so as to secure the hardness suitable for the composition and section of rail being treated.

The usual method of testing the toughness of rails is the drop test. A 6-foot length of rail is supported at the ends, and a 2,000-pound weight is dropped upon it from a height of about 20 feet, striking the rail midway between the supports. Hundreds of tests of Brunorized rails have been made in comparison with controlled-cooled rails to determine: First, number of blows before failure; second, percentage of tests requiring six blows for destruction; third, elongation after last blow; and, fourth, Brinell hardness. In the test for ductility, the Brunorized rail was found to be superior; and the number of the tests made it clear that that improvement is not only a definite but also a very marked one.

Another outstanding advantage of steel produced by the new method is its increased toughness at low temperatures. While Brunorized rails may at times be a little less hard than hot-bed-cooled rails and controlled-cooled rails, and may have slightly lower tensile strength and, therefore, a slightly lower tensile yield point, nevertheless all this is more than offset by their far greater ductility and toughness, which are the direct result of the fine grain structure obtained by Brunorizing. Furthermore, preliminary data of tests of impact values at low temperatures indicate that Brunorized rails are much tougher at zero Fahrenheit, the difference at 50° below zero being very striking. This factor is of considerable importance, and is expected to have a beneficial effect on rails during periods of cold weather.

EUROPEAN HIGHWAYS

IT WILL soon be possible to drive 1,940 miles from London to Istanbul (Constantinople) on a paved highway superior to any of equal length in the United States. The road has already been completed as far eastward as Szeged, on the Hungary-Yugoslavia border, approximately three-fifths of the total length. Although it crosses nine countries, it will conform throughout to certain minimum requirements adopted at a conference of delegates from the various nations at Budapest in September, 1935.

Some of these standards, which are given in an article by Robert B. Brooks in *Civil Engineering*, should interest American highway builders and the motoring public. They provide, among other things, for: A normal maximum grade of 5 per cent, which may rise as high as 10 per cent on short sections in mountainous terrain; a minimum width of 19½ feet, which shall be increased to from 26½ to 29½ feet where traffic is considerable, with divided lanes where it is heavy in both directions; the acquisition of sufficient land on either side to permit future widening; shoulders at least 6½ feet wide and sufficiently consolidated to accommodate traffic in emergencies; bridges and other structures of the same width as sections approaching them, and designed so as to permit widening and strengthening later on; and foot and bicycle paths, particularly near the larger towns.

Traffic signs will be uniform and in accordance with recommendations of the Geneva Convention of 1931. All grade crossings will be protected with sound devices or luminous signs perceptible under all weather conditions. The formalities of registering motor vehicles will be made uniform in all the countries along the route. The alignment, grade, and other characteristics of the highway are such that the 1,940-mile trip can, it is expected, be made in five days. To illustrate its ease of driving, a racer traveled a considerable section of it at an average speed of 200 miles an hour.

In addition to this outstanding international thoroughfare, first-class highways are being built in various European countries. Great Britain has approved a 5-year program calling for expenditures of $650,000,000. Germany is far advanced on the construction of 4,000 miles of double highways that will interconnect all important industrial cities in the country and extend to every strategic point on the borders. There are four classes of roads in Germany, of which the *Autobahn* here referred to is the first. Its standard over-all width is 24 meters (78.7 feet). It consists of two strips of reinforced concrete, each 24.6 feet wide and spaced 16.4 feet apart. In the central zone are two bicycle paths and a parkway planted with shrubs and grass designed to kill the glare from headlights of approaching vehicles. Outside of each concrete strip is a walkway composed of cubes of stone with tarred joints, and beyond it a shoulder one meter (3.28 feet) wide. Approximately 600 miles of these super-highways are to be completed by January 1, 1937.

DOCTOR MEAD'S SUCCESSOR

ON THE first anniversary of the death of Dr. Elwood Mead, for many years Commissioner of the U. S. Bureau of Reclamation, John C. Page was sworn in as his successor. That such a long period was permitted to elapse before making the appointment is significant, as it indicates the care with which the matter was considered.

The new occupant of the post that Doctor Mead so ably filled is a Mead-trained man, and has many things in common with his late, illustrious mentor, including a western birthright. Mr. Page is a graduate of the University of Nebraska, and has spent 27 of his 50 years in the work of the bureau he now heads. His well-rounded experience in all phases of the bureau's activities gives him a clear understanding of the problems of the arid and semiarid West. He served as office engineer and chief administrative assistant to Doctor Mead during the construction of Boulder Dam.

NEPTUNE'S RICHES

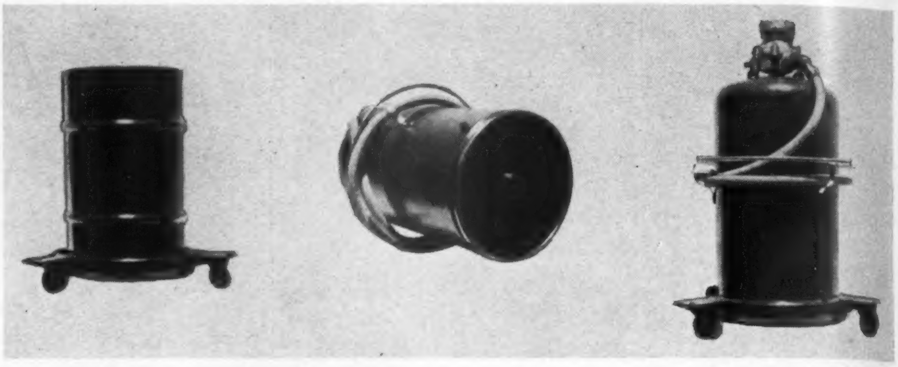
ECONOMISTS often point out that the United States cannot go forward as fast in the future as it has in the past because we have squandered much of our rich endowment of natural resources. The same school of thought propounds the theory that some new discovery or invention such as the automobile or the radio must be made if any considerable proportion of the jobless is to be reëmployed.

There may be a sound basis for much of the apprehension that is felt for our future welfare; but those who can see only blackness ahead might do well to look toward the sea. It constitutes a natural resource of vast richness that scarcely has been touched. Chemists are gradually developing methods for reclaiming some of its treasures, however; and it is within the bounds of reason to visualize extensive plants along the shores ten or more years hence. Their construction and operation may create a tide of employment undreamed of today.

Encouraging this mental picture are the results of the bromide recovery plant which the Ethyl-Dow Chemical Company has been operating for nearly three years on a beach close to Wilmington, N. C. The *Southern Power Journal* reports that in treating one square mile of ocean, 172 feet deep, more than 10,000 tons of bromine was obtained. Unrecovered, and washed back into the sea, however, were more than 5,650,000 tons of materials that had a current market value of $166,000,000. Chief among them were: Sodium chloride—4,160,000 tons worth $55,700,000; magnesium sulphate—1,055,000 tons, $40,100,000; calcium chloride—229,000 tons, $5,040,000; potassium chloride—118,600 tons, $9,490,000; magnesium—95,200 tons, $47,600,000; aluminum—270 tons, $102,600; strontium carbonate—314 tons, $188,500; iron—284 tons, $17,050; copper—18 tons, $3,420; iodine—6.28 tons, $18,820; silver—3.07 tons, $57,200; and gold—0.098 tons valued at $82,400.

Portable Pneumatic Lubricator for Service Stations

A NEW oil dispenser for servicing automotive vehicles has been put on the market by the Balanced Pressure Equipment Company. It is designed to deliver the lubricant directly from the original container to the transmissions, rear axles, etc., with compressed air, which is now available at all up-to-date service stations for charging tires. The equipment consists of two parts—of a base on casters, and of a dome. The latter has a centrally disposed outlet pipe with an automatic shut-off valve at its lower end, and is provided with a hose and nozzle, a pressure gauge, air valves, and an encircling member that serves to hold the hose when the lubricator is not in use and also as a handle by which to lift the dome and to move the unit around. Assembly is effected quickly, and involves setting a drum of oil on the base; lowering the dome down over it with the pipe inserted in the drum opening; and clamping the dome airtight to the base.

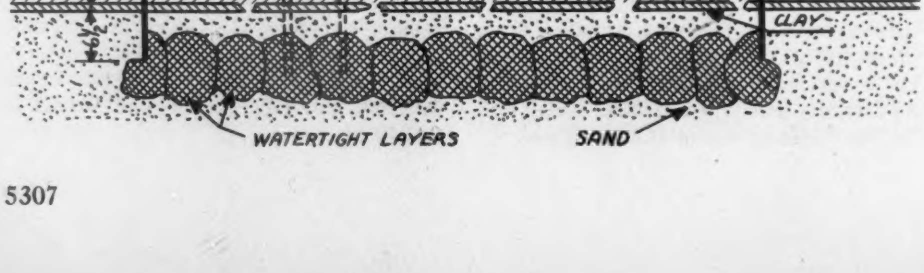


The dispenser operates on the balanced-pressure principle. That is, when compressed air is admitted into the dome it exerts equal pressure on the outside and on the inside of the drum so that it cannot possibly burst, a danger that always exists when pressure is applied only on the inside. There are no moving parts to get out of order; and the unit is ready for service as soon as compressed air is introduced. It is said to work neatly and without wastage; and as the outlet pipe reaches almost to the bottom of the container, most of the lubricant can be applied under pressure. In addition to a dispenser for a 100-pound drum, the company is prepared to furnish any size that may be desired either for single drums or a group of drums.

Pervious Soils Made Watertight with Asphalt Emulsions

IN OUR July, 1936, issue we described how pervious subsoils could be made impervious by bentonite forced underground with compressed air. Now we learn from a paper presented at the International Conference of Soil Mechanics and Foundation Engineering of kindred work done abroad with an asphalt emulsion for fine soils and with a mixture of asphalt emulsion and cement grout for coarse soils and fissured rock. In the case of the former, the dilution is about as thin as water and is forced down to the stratum to be treated through a series of pipes and under moderate pressure. Coagulants that can be fixed to act at any predetermined time from a few minutes to several days are added to the emulsion to induce agglomeration of the particles of bitumen. Material fine enough to permit 90 per cent of it to pass a 40 screen has been made watertight by this process.

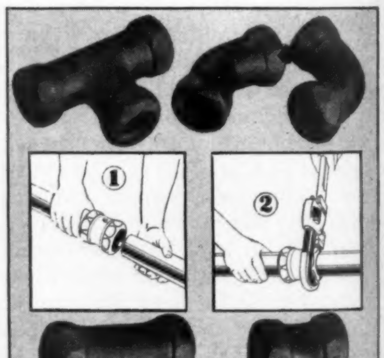
As an example of what can be accomplished with the emulsion is cited a bridge job in Holland. In building one of the piers inside a cofferdam of steel sheet piling, some of the foundation piles penetrated a layer of clay, permitting water to enter and to fill the excavation, which covered 22x75 square feet. Within this area 60 pipes were driven to a point just below the bottom of the sheet piling, and the pervious sand thoroughly saturated and made impermeable with the asphalt injected through them. The accompanying drawing, reproduced through the courtesy of *Engineering News-Record*, shows the general arrangement and result of the work.



Standard Fittings Eliminate Pipe-Threading

"TIME OUT" for cutting pipe to exact lengths, threading, grooving, flaring, or screwing up joints in cramped quarters, is no longer necessary, according to an announcement made by the S. R. Dresser Manufacturing Company, 370 Fisher Avenue, Bradford, Pa. With the standard line of new Dresser fittings, Style 65, nothing but an ordinary wrench is needed to complete a joint in a few moments.

After inserting the plain-end pipe into the fitting, which comes completely assembled, it is necessary only to tighten two threaded octagonal follower nuts with a few quick turns of the wrench. As this is done, resilient, armored gaskets at each end of the fitting are compressed tightly around the pipe, forming a positive seal. The resulting joint, it is pointed out, is not only permanently tight but absorbs normal vibration, expansion and contraction movement, and permits deflections of the pipe in the joint. If a pipe is already threaded, it also can be joined in the same way.



The complete line of Style 65 fittings includes standard and extra-long couplings, ells (both 45° and 90°), and tees, all supplied in standard steel-pipe sizes ranging from ½ inch to 2 inches, inside dimensions, black or galvanized. These fittings are recommended by the manufacturer for simplifying joint-making and repair work both on the inside and the outside of piping for oil, gas, water, air, or other industrial lines. The principle on which they are based is essentially the same as that used in other styles of the well-known Dresser Coupling.

This and That

Dobbin Still a Factor

Despite the pronounced tendency towards mechanization, the production of horse-drawn vehicles and of wheelbarrows in the United States increased measurably in 1935, according to the Department of Commerce census returns. Unemployment relief may have bolstered the wheelbarrow business; but the greatest market for the horse-drawn vehicle was the farm. The total value of the products in the two classes for that year was $8,795,364, wheelbarrows alone accounting for $1,950,255.

★ ★ ★

Use of Dam Models Growing

The use of models for the preconstruction study of dams and other hydraulic structures is becoming a recognized engineering practice. The *Reclamation Era*, published by the U. S. Bureau of Reclamation, points out that there are now more than twenty laboratories in this country where such work is conducted. Three of them, all located in Colorado, are maintained by the bureau, and models built there have importantly influenced the design of various structures. In the case of Imperial Dam, which will divert water from the Colorado River into the All-American Canal, the design of the headworks was based entirely upon expedients proposed and tried out with models. Likewise, a model contributed important information towards the working out of a satisfactory construction schedule for Grand Coulee Dam. In the case of another dam, a proposed type of spillway crest was abandoned because model tests showed it to be impractical. The models ordinarily range from 2x6 feet to 8x20 feet in dimensions. They are principally made of wood, sheet metal, cement, plaster, and pyralin—the last-mentioned material being a transparent celluloid that is obtainable in sheets and can be pressed into wooden molds to produce scroll cases and draft tubes. It has made it possible to take motion pictures of the flow of water through tunnels and gates. The idea of using models as adjuncts to engineering designs originated in Europe.

★ ★ ★

Shipping Via the Airways

If further evidence of the fact that we are living in an ultramodern world were required, it might be found in the recent announcement by an American express agency that it is prepared to aid housewives to shop by air. Through the medium of such a service, it is pointed out, it is possible to telephone orders that will bring to one's kitchen within 24 hours the choicest foods that the nation offers. By way of illustration, the express company suggests a dinner including Florida guavas, New Orleans gumbo, Bimini stone crabs or Miami rock lobsters, turtle steaks or Virginia baked ham, hearts-of-palm salad from Florida, and candied fruits from the same state.

★ ★ ★

"Salters" at Work Again

The expression "salting," which means the surreptitious enrichment of ore, is usually associated with the wild-and-woolly days of the Old West, but now and then instances of the practice of this form of deception come to light. Right now there is a mysterious case of it in Canada. All the facts are not yet in hand, although every effort is being made to determine them.

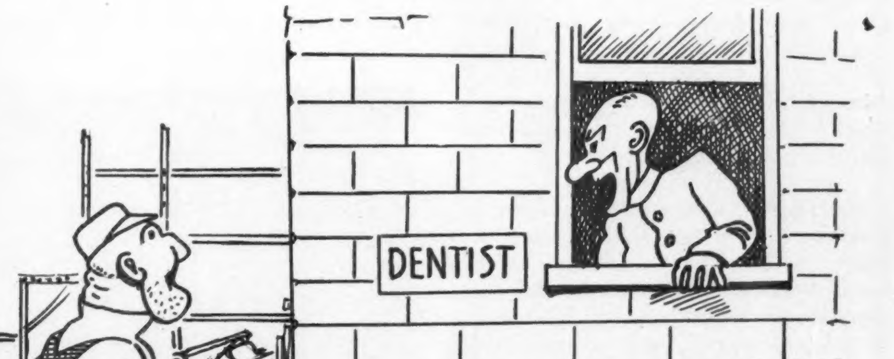
Rubec Mines, in Quebec Province, last fall engaged a reputable diamond-drilling contractor to take cores of its property. The first fourteen holes revealed nothing of importance; but the fifteenth showed unusually high values from assay returns. Holes 16 and 17 indicated continuation of the favorable ore bodies for a distance of 1,500 feet. Hole 18, which was near No. 15, disclosed the richest samples of all, as it penetrated four streaks that apparently carried ore containing from 31.37 to 47.12 ounces of gold per ton.

Not wishing to fool themselves, the company officials decided to have the results checked by an independent authority. Meanwhile, accounts of the richness of the cores had been made public and the shares had skyrocketed, so the company asked the Ontario Securities Commission to make an examination of its property. That body retained Colin A. Campbell, mining engineer, to conduct a thorough investigation. At its conclusion, Mr. Campbell reported that he had been unable to find values greater than 35 cents per ton in any of the cores. The evidence indicated clearly that the samples previously assayed had been salted, but that neither the core-drilling contractor nor the Rubec officials had any knowledge of those acts. With the full coöperation of the company, the Ontario Securities Commission is making a study of the case in an effort to learn the identity of the perpetrators of the attempted fraud. The assumption is that their purpose was to profit through a rise in the market value of the company's stock.

★ ★ ★

Model School Mine

Students of the mining and civil engineering classes at the University of Utah will soon have a completely equipped model mine on the campus to serve as a laboratory of practical instruction. For more than a year, between 50 and 60 men have been employed on the project, which is being financed by a $29,000 allocation of Federal funds. The mine has two levels opening from a vertical shaft and connected by an inclined winze. Drifts and crosscuts are 5 feet wide by 6½ feet high, and are timbered and lagged. They have purposely been made irregular to create difficult conditions for classes in mine surveying. When completed, this mine is expected to be the finest of its kind in the country.



"Hey, shut off that thing. The customers in the waiting room think it's me!"

Industrial Notes

Research engineers of the International Nickel Company recently have been granted a patent on a special alloy of iron and nickel that is said to be so hard that it will scratch glass. It is intended primarily for the making of machinery parts that are subjected to much wear and abrasion in service.

The research department of the German leather industry has developed a process for the preservation of hides and skins that is said to be a marked improvement upon salting with its objectionable salt spots. Sodium chloride and zinc oxide are used—the proportion in the case of 7,275 pounds of calf skins, for example, being 2,200 pounds of sodium chloride and 27.5 pounds of zinc oxide.

A nozzle with a double air jet is the principal feature of a new spray gun offered by the O. Hommel Company. The result, according to the maker, is a wider fan of spray and complete atomization of the fluid with air at lower pressure and with less air consumption than is ordinarily the case. Compared with a gun with the customary single-jet holes, the new type of nozzle operates 25 per cent faster when using air at 25 pounds pressure and prevents "splitting" at the edge of the fan.

The U. S. Bureau of Mines has recently announced the development of a new method of computing the compressibility of gases by which it is not necessary to measure volume but only pressure and temperature to obtain precise figures. It is the outcome of laboratory work conducted in the Government helium plant at Amarillo, Tex., under the direction of E. S. Burnett, and is of vital importance to the gas industry generally because it eliminates error, which is unavoidable with the complex procedure now in common use.

Steel rails 120 feet long are being experimented with by the London North-Eastern Railway on a section of its main line over which the *Silver Jubilee* and other express trains travel regularly at a speed of 90 miles an hour. Each rail weighs 1¾ long tons; and 100 tons of them were rolled at the mill of the Skinningrove Iron Company, Saltburn, Yorkshire. They are probably the longest 1-piece rails that have ever been produced, and have been laid in an attempt to reduce the number of joints in tracks and thereby to lessen noise and to promote smoother travel. The average rail is 39 feet long.

If all the claims made for a recent invention be correct, then rubber may soon be shipped from plantations not in the familiar sheets but in the form of tiny particles that look not unlike sawdust. According to *The Building Times*, a London publication, the latex, as it comes from the trees, is forced through jets with compressed air and is deposited on a stainless-steel belt which is kept moving in a heated "tunnel" until all the moisture has been extracted. The resultant product is rubber in its purest form ready to be manufactured into the manifold articles of the industry. Sheet rubber must first be broken up or masticated in special machines, which are costly.

What is probably one of the most complete manuals on the subject of industrial packings has been compiled and published by the United States Rubber Products, Inc., one of the oldest concerns in the field. In addition to full data dealing essentially with the company's numerous products, the 112-page book contains much other useful and related information such as charts of specific gravities and of the temperature of steam at different pressures, Centigrade-Fahrenheit and metric conversion tables, as well as tables giving the melting points of materials and their weights, etc., etc. The manual was prepared primarily to help plant operators, engineers, and executives select the proper "U.S." packing for each specific need.

Designed primarily for the removal of heavy accumulations of oil and grease from airplane engines and parts, the Hydro-Degreaser made by the Curran Corporation is apparently being used to advantage in other industrial plants, including jewelry establishments where similar work has to be done. It consists of two tanks, one for cleaning and one for rinsing. The oil-coated and greasy articles are immersed in the cleaning bath, a solvent that is said to have a powerful affinity for waxes and buffing compounds and to remove every trace of them without damaging soft metals. The bath is cold and, if necessary, is agitated with compressed air to speed up operations. After they have soaked for a few minutes, the parts are transferred to the second tank where they are washed with a stream of water from a hose. There the treated grease is quickly emulsified, leaving, to quote the manufacturer, a perfectly clean, dry surface without an oily film. The process does not call for the use of steam or gas heat; and the solvent, known as Gunk, is noninjurious to the skin.

Under the trade name of Harbkoat, the W. E. Harber Company has put on the market a liquid coating for the protection of refractories. The basic material is a special grade of silicon carbide that is made into a paste and has to be mixed with water before application. It may be brushed or sprayed on to the exposed surfaces of firebrick in place, or the refractory may be similarly treated or immersed in the viscous fluid before it is part of a furnace or other similar structure. It air dries, it is claimed, in a few hours, and when heated forms a thin glaze that effectually seals all cracks; and that has high thermal conductivity; and that will remain unaffected at temperatures up to 3,300°F. Clinkers, ashes, and soot will not adhere to the hard, smooth film, which also prevents spalling and abrasion of the brick as well as infiltration of air and escape of hot gases. One gallon of Harbkoat will cover on an average 100 square feet of new fireclay or brick, and costs, including application, approximately ten cents per square foot.

UNIQUE USE OF PAVING BREAKER

At a dangerous street intersection in Sanford, Me., a motorist recently ran into a "Stop" sign, breaking the standard on which it was mounted and knocking the sign to the ground. To effect temporary repairs, workers of the State Highway Department drove the moil-pointed steel of a CC-45 paving breaker into the road surface and lashed the sign to the tool, as shown in the picture. This makeshift sufficed to warn drivers until a permanent installation could be made.